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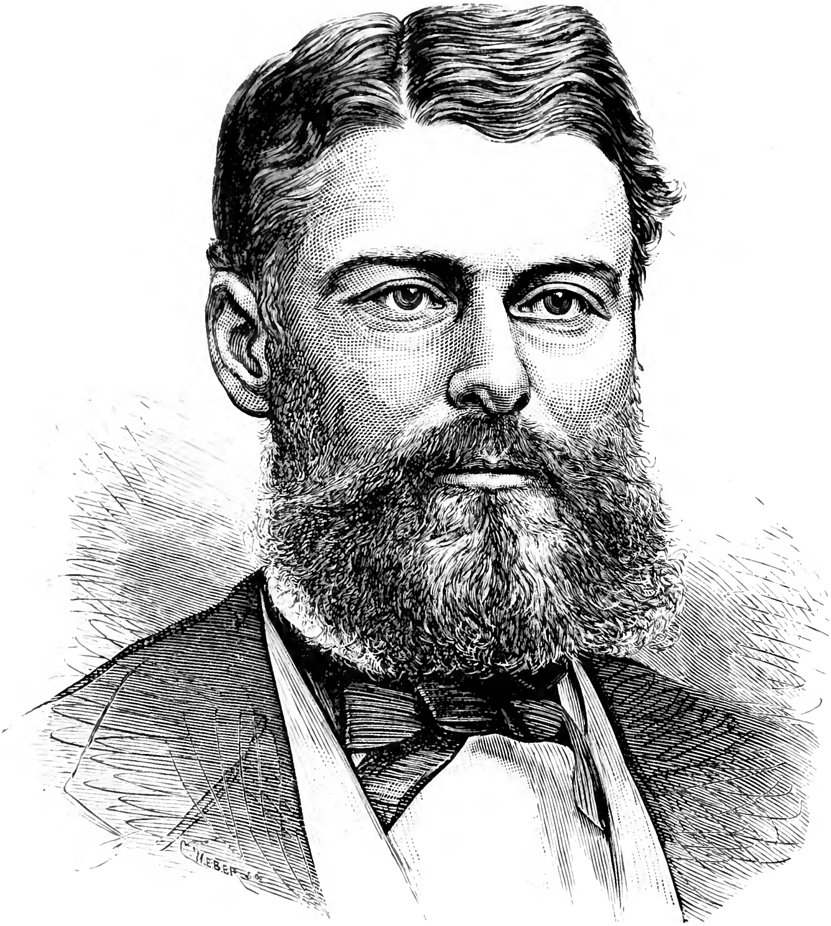

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MAY, 1881.

STORY OF A SALMON.

By Professor DAVID S. JORDAN.

IN the realm of the Northwest Wind, on the boundary-line between the dark fir-forests and the sunny plains, there stands a mountain, a great white cone two miles and a half in perpendicular height. On its lower mile, the dense fir-woods cover it with never-changing green; on its next half-mile, a lighter green of grass and bushes gives place in winter to white; and, on its uppermost mile, the snows of the great Ice age still linger in unspotted purity. The people of Washington Territory say that this mountain is the great "King-pin of the Universe," which shows that, even in its own country, Mount Rainier is not without honor.

Flowing down from the southwest slope of Mount Rainier is a cold, clear river fed by the melting snows of the mountain. Madly it hastens down over white cascades and beds of shining sands, through birch-woods and belts of dark firs to mingle its waters at last with those of the great Columbia.

This river is the Cowlitz, and on its bottom, not many years ago, there lay half-buried in the sand a number of little orange-colored globules, each about as large as a pea. These were not much in themselves, but, like the philosopher's monads, each one had in it the promise and potency of an active life. In the water above them, little suckers and chubs and prickly sculpins were straining their mouths to draw these globules from the sand, and vicious-looking crawfishes picked them up with their blundering hands and examined them with their telescopic eyes. But one, at least, of the globules escaped their scientific curiosity, else this story would not be worth telling.

The sun shone down on it through the clear water, and the ripples of the Cowlitz said over it their incantations, and in it at last awoke a

living being. It was a fish, a curious little fellow, only half an inch long, with great, staring eyes which made almost half his length, and a body so transparent that he could not cast a shadow. He was a little salmon, a very little salmon, but the water was good, and there were flies, and worms, and little living creatures in abundance for him to eat, and he soon became a larger salmon. And there were many more little salmon with him, some larger and some smaller, and they all had a merry time. Those who had been born soonest and had grown largest used to chase the others around and bite off their tails, or, still better, take them by the heads and swallow them whole, for, said they, "Even young salmon are good eating." "Heads I win, tails you lose" was their motto. Thus, what was once two small salmon became united into one larger one, and the process of "addition, division, and silence," still went on.

By-and-by, when all the salmon were too small to swallow the others, and too large to be swallowed, they began to grow restless and to sigh for a change. They saw that the water rushing by seemed to be in a great hurry to get somewhere, and one of them suggested that its hurry was caused by something good to eat at the other end of its course. Then they all started down the stream, salmon-fashion, which fashion is to get into the current, head up-stream, and so to drift backward as the river sweeps along.

Down the Cowlitz River they went for a day and a night, finding much to interest them which we need not know. At last, they began to grow hungry, and, coming near the shore, they saw an angle-worm of rare size and beauty floating in an eddy of the stream. Quick as thought one of the boys opened his mouth, which was well filled with teeth of different sizes, and put it around that angle-worm. Quicker still he felt a sharp pain in his gills, followed by a smothering sensation, and in an instant his comrades saw him rise straight into the air. This was nothing new to them, for they often leaped out of the water in their games of hide-and-seek, but only to come down again with a loud splash not far from where they went out. But this one never came back, and the others went on their course wondering.

At last they came to where the Cowlitz and the Columbia join, and they were almost lost for a time, for they could find no shores, and the bottom and the top of the water were so far apart. Here they saw other and far larger salmon in the deepest part of the current, turning neither to the right nor left, but swimming straight on up just as rapidly as they could. And these great salmon would not stop for them, and would not lie and float with the current. They had no time to talk, even in the simple sign-language by which fishes express their ideas, and no time to eat. They had an important work before them, and the time was short. So they went on up the river, keeping their great purposes to themselves, and our little salmon and his friends from the Cowlitz drifted down the stream.

By-and-by the water began to change. It grew denser, and no longer flowed rapidly along, and twice a day it used to turn about and flow the other way. And the shores disappeared, and the water began to have a different and peculiar flavor—a flavor which seemed to the salmon much richer and more inspiring than the glacier-water of their native Cowlitz. And there were many curious things to see; crabs with hard shells and savage faces, but so good when crushed and swallowed! Then there were luscious squid swimming about, and, to a salmon, squid are like ripe peaches and cream for dinner. There were great companies of delicate sardines and herring, green and silvery, and it was such fun to chase them and to capture them!

Those who eat only sardines, packed in oil by greasy fingers, and herrings dried in the smoke, can have little idea how satisfying it is to have one's stomach full of them, plump and sleek, and silvery, fresh from the sea.

Thus they chased the herrings about and had a merry time. Then they were chased about in turn by great sea-lions, swimming monsters with huge half-human faces, long thin whiskers, and blundering ways. The sea-lions liked to bite out the throats of the salmon, with their precious stomachs full of luscious sardines, and then to leave the rest of the fish to shift for itself.

And the seals and the herrings scattered the salmon about, and at last the hero of our story found himself quite alone, with none of his own kind near him. But that did not trouble him much, and he went on his own way, getting his dinner when he was hungry, which was all the time, and then eating a little between-meals for his stomach's sake.

So it went on for three long years; and at the end of this time our little fish had grown to be a great, fine salmon, of forty pounds' weight, shining and silvery as a new tin pan, and with rows of the loveliest round black spots on his head, and back, and tail. One day, as he was swimming about, idly chasing a big sculpin, with a head so thorny that he never was swallowed by anybody, all of a sudden the salmon noticed a change in the water around him.

Spring had come again, and the south-lying snow-drifts on the Cascade Mountains once more felt that the "earth was wheeling sunward," and the cold snow-waters ran down from the mountains and into the Columbia River, and made a freshet on the river, and the high water went far out into the sea, and out in the sea our salmon felt it on his gills; and he remembered how the cold water used to feel in the Cowlitz when he was a little fish, and in a blundering, fishy fashion he thought about it, and wondered whether the little eddy looked as it used to, and whether caddice-worms and young mosquitoes were really as sweet and tender as he used to think they were; and he thought some other things, but, as a salmon's mind is located in the optic lobes of his brain, and ours in a different place, we can not be

certain, after all, what his thoughts really were. What he did we know. He did what every grown salmon in the ocean does when he feels the glacier-water once more upon his gills. He became a changed being. He spurned the blandishments of soft-shelled crabs. The pleasures of the table and of the chase, heretofore his only delights, lost their charms for him. He turned his course straight toward the direction whence the cold fresh water came, and for the rest of his life he never tasted a mouthful of food. He moved on toward the river-mouth, at first playfully, as though he were not really certain whether he meant anything, after all. Afterward, when he struck the full current of the Columbia, he plunged straight forward with an unflinching determination that had in it something of the heroic. When he had passed the rough water at the bar, he found that he was not alone; his old neighbors of the Cowlitz and many more, a great army of salmon, were with him. In front were thousands; pressing on, and behind them, were thousands more, all moved by a common impulse, which urged them up the Columbia.

They were swimming bravely along where the current was deepest, when suddenly the foremost felt something tickling like a cobweb about their noses and under their chins. They changed their course a little to brush it off, and it touched their fins as well. Then they tried to slip down with the current, and thus to leave it behind. But no—the thing, whatever it was, although its touch was soft, refused to let go, and held them like a fetter; and, the more they struggled, the tighter became its grasp. And the whole foremost rank of the salmon felt it together, for it was a great gill-net, a quarter of a mile long, and stretched squarely across the mouth of the river. By-and-by men came in boats and hauled up the gill-net and threw the helpless salmon into a pile on the bottom of the boat, and the others saw them no more. We that live outside the water know better what befalls them, and we can tell the story which the salmon could not.

All along the banks of the Columbia River, from its mouth to nearly thirty miles away, there is a succession of large buildings, looking like great barns or warehouses, built on piles in the river, and high enough to be out of the reach of floods. There are thirty of these buildings, and they are called canneries. Each cannery has about forty boats, and with each boat are two men and a long gill-net, and these nets fill the whole river as with a nest of cobwebs from April to July; and to each cannery nearly a thousand great salmon are brought in every day. These salmon are thrown in a pile on the floor; and Wing Hop, the big Chinaman, takes them one after another on the table, and with a great knife dexterously cuts off the head, the tail, and the fins; then with a sudden thrust removes the intestines and the eggs. The body goes into a tank of water, and the head goes down the river to be made into salmon-oil. Next, the body is brought on another table, and Quong Sang, with a machine like a feed-cutter,

cuts it into pieces just as long as a one-pound can. Then Ah Sam, with a butcher-knife, cuts these pieces into strips just as wide as the can. Then Wan Lee, the China boy, brings down from the loft, where the tinners are making them, a hundred cans, and into each can puts a spoonful of salt. It takes just six salmon to fill a hundred cans. Then twenty Chinamen put the pieces of meat into the cans, fitting in little strips to make them exactly full. Then ten more solder up the cans, and ten more put the cans in boiling water till the meat is thoroughly cooked, and five more punch a little hole in the head of each can to let out the air. Then they solder them up again, and little girls paste on them bright-colored labels showing merry little Cupids riding the happy salmon up to the cannery-door, with Mount Rainier and Cape Disappointment in the background; and a legend underneath says that this is "Booth's" or "Badollet's Best," or "Hume's" or "Clark's," or "Kinney's Superfine Salt-water Salmon." Then the cans are placed in cases, forty-eight in a case, and five hundred thousand cases are put up every year. Great ships come to Astoria and are loaded with them, and they carry them away to London, and San Francisco, and Liverpool, and New York, and Sydney, and Valparaiso, and Skowhegan, Maine; and the man at the corner grocery sells them at twenty cents a can.

All this time our salmon is going up the river, escaping one net as by a miracle, and soon having need of more miracles to escape the rest; passing by Astoria on a fortunate day, which was Sunday, the day on which no man may fish if he expects to sell what he catches, till finally he came to where nets were few, and, at last, to where they ceased altogether. But here he found that scarcely any of his many companions were with him, for the nets cease when there are no more salmon to be caught in them. So he went on day and night where the water was deepest, stopping not to feed or loiter on the way, till at last he came to a wild gorge, where the great river became an angry torrent rushing wildly over a huge staircase of rocks. But our hero did not falter, and, summoning all his forces, he plunged into the Cascades. The current caught him and dashed him against the rocks. A whole row of silvery scales came off and glistened in the water like sparks of fire, and a place on his side became black and red, which, for a salmon, is the same as being black and blue for other people. His comrades tried to go up with him; and one lost his eye, one his tail, and one had his lower jaw pushed back into his head like the joints of a telescope. Again he tried to surmount the Cascades, and at last he succeeded, and an Indian on the rocks above was waiting to receive him. But the Indian with his spear was less skillful than he was wont to be, and our hero escaped, losing only a part of one of his fins, and with him came one other, and henceforth these two pursued their journey together.

Now a gradual change took place in the looks of our salmon. In the sea he was plump and round and silvery, with delicate teeth, and

as handsome and symmetrical a mouth as any one need wish to kiss. Now his silvery color disappeared, his skin grew slimy, and the scales sank into it; his back grew black and his sides turned red—not a healthy red, but a sort of hectic flush. He grew poor, and his back, formerly as straight as need be, now developed an unpleasant hump at the shoulders. His eyes—like those of all enthusiasts who forsake eating and sleeping for some loftier aim—became dark and sunken. His symmetrical jaws grew longer and longer, and, meeting each other, as the nose of an old man meets his chin, each had to turn aside to let the other pass. And his beautiful teeth grew longer and longer, and projected from his mouth, giving him a savage and wolfish appearance, quite unlike his real disposition. For all the desires and ambitions of his nature had become centered into one. We do not know what this one was, but we know that it was a strong one, for it had led him on and on, past the nets and horrors of Astoria, past the dangerous Cascades, past the spears of the Indians, through the terrible flume of the Dalles, where the mighty river is compressed between huge rocks into a channel narrower than a village street; on past the meadows of Umatilla and the wheat-fields of Walla Walla; on to where the great Snake River and the Columbia join; on up the Snake River and its eastern branch, till at last he reached the foot of the Bitter-Root Mountains in the Territory of Idaho, nearly a thousand miles from the ocean, which he had left in April. With him still was the other salmon which had come with him through the Cascades, handsomer and smaller than he, and, like him, growing poor and ragged and tired. At last, one October afternoon, they came together to a little clear brook, with a bottom of fine gravel, over which the water was but a few inches deep. Our fish painfully worked his way to it, for his tail was all frayed out, his muscles were sore, and his skin covered with unsightly blotches. But his sunken eyes saw a ripple in the stream, and under it a bed of little pebbles and sand. So there in the sand he scooped out with his tail a smooth, round place, and his companion came and filled it with orange-colored eggs. Then our salmon came back again, and, softly covering the eggs, the work of their lives was done, and, in the old salmon-fashion, they drifted tail foremost down the stream.

Next morning, a settler in the Bitter-Root region, passing by the brook near his house, noticed that a "dog-salmon" had run in there and seemed "mighty nigh tuckered out." So he took a hoe, and, wading into the brook, rapped the fish on the head with it, and carrying it ashore threw it to the hogs. But the hogs had a surfeit of salmon-meat, and they ate only the soft parts, leaving the head untouched. And a wandering naturalist found it there, and sent it to the United States Fish Commission to be identified, and thus it came to me.

PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

GYMNASTICS.

"Force begets Fortitude and conquers Fortune."—Helvetius.

PHYSICAL vigor is the basis of all moral and bodily welfare, and a chief condition of permanent health. Like manly strength and female purity, gymnastics and temperance should go hand in hand. An effeminate man is half sick; without the stimulus of physical exercise, the complex organism of the human body is liable to disorders which abstinence and chastity can only partly counteract. By increasing the action of the circulatory system, athletic sports promote the elimination of effete matter and quicken all the vital processes till languor and dyspepsia disappear like rust from a busy plowshare. "When I reflect on the immunity of hard-working people from the effects of wrong and overfeeding," says Dr. Boerhaave, "I can not help thinking that most of our fashionable diseases might be cured *mechanically instead of chemically*, by climbing a bitterwood-tree or chopping it down, if you like, rather than swallowing a decoction of its disgusting leaves." The medical philosopher, Asclepiades, Pliny tells us, had found that health could be preserved, and if lost, restored, by physical exercise alone, and not only discarded the use of internal remedies, but made a public declaration that he would forfeit all claim to the title of a physician if he should ever fall sick or die but by violence or extreme old age. Asclepiades kept his word, for he lived upward of a century, and died from the effects of an accident. He used to prescribe a course of gymnastics for every form of bodily ailment, and the same physic might be successfully applied to certain moral disorders, incontinence, for instance, and the incipient stages of the alcohol-habit. It would be a remedy *ad principium*, curing the symptoms by removing the cause, for some of the besetting vices of youth can with certainty be ascribed to an excess of that potential energy which finds no outlet in the functions of our sedentary mode of life. In large cities parents owe their children a provision for a frequent opportunity of active exercise, as they owe them an antiseptic diet in a malarious climate.

Nor can this obligation be evaded by depreciating the importance of physical culture as distinct from that of the mental faculties. For the term of their earthly pilgrimage the human body and the most immortal soul are more inseparable and more interdependent than the horse and its rider: a Centaur would hardly have promoted his higher interests by neglecting the equine part of his person. "I have sinned against my brother, the Ass," said St. Francis, when the abuse of his

body had brought on a mortal disease. For the idea that the supremacy of the mind could be enforced by debilitating penances is a fatal mistake; an enervated body, instead of ministering to the needs of the mind, becomes its tyrant, a querulous, capricious, and exorbitant master. Every hospital attendant knows that, with the rarest exceptions, the sufferers from exhausting diseases have no more self-control than a fretful child. Neither can the progress of our mechanical industries be made a pretext for undervaluing the advantages of an athletic education. It has been prophesied that the time will come when the autocrat of the breakfast-table shall break his egg with a dynamite wafer; but, unless we invent a labor-saving contrivance for every muscle of the human organism, there is not a day in the year nor an hour in the day when the practical business of life can not be performed more easily and more pleasantly with the aid of a vigorous body, not to re-mention the moral disadvantages which never fail to attend the loss of manly self-reliance. Active exercises also confer beauty of form and a natural grace of deportment. "By their system of physical culture," says a Scotch author, "the Greeks realized that beautiful symmetry of shape which for us exists only in the ideal, or in the forms of divinity which they sculptured from figures of such perfect proportions."

That a man's welfare in every sense of the word depends upon the normal development of his body might, therefore, seem an axiom whose self-evidence could be questioned only in a fit of insane infatuation; yet an Oriental fanatic has succeeded in tainting countless millions of his fellow-men with this very insanity. About six hundred years before the beginning of our chronological era, a speculative philosopher of northern Hindostan set about to investigate the origin of the sufferings which so often make human life a burden instead of a blessing, and, failing to trace these afflictions to any avoidable cause, he took it into his head that terrestrial existence itself must be an evil, and conceived the unhappy idea of preaching a crusade against the love of earth and the rights of the human body, as distinct from a supposed preternatural part of our being. His success has been, beyond all compare, the greatest calamity that ever befell the human race since the days of the traditional deluge; not only that the doctrines of Gautama bore their fruit in the utter physical degeneration of his native country, and the populous empires of Eastern Asia, but, seven centuries after, the essential doctrines of Buddhism, intensified by an admixture of Gnostic demonism and Hebrew mythology, were preached upon the shores of the Mediterranean and invaded the paradise of the Aryan nations. A mania of self-torture and miracle-worship broke out like a mental epidemic, and, at the very time when the influence of Grecian civilization began to wane, the new creed spread into Italy, and the friends of science and freedom were confronted with the fearful danger of an anti-natural religion. What that danger meant, our liberated age can hardly realize unless we review the

fate of those nations to whom salvation came too late ; on whose destiny the curse of that superstition has been wrought out to the bitter end. The attempt to carry the theories of the Hebrew fanatics into practice led to a state of affairs against which the *unpossessed* part of mankind had to combine in sheer self-defense ; the maniacs were overpowered, but only after a struggle which has trampled the chief battle-fields into dust, and not before they had turned the Mediterranean God-garden into such a pandemonium of madness, tyranny, and wretchedness, that the lot of the African savages appeared heaven in comparison. The annals of pagan despotism furnish no parallel to the pages stained with blood and tears that record the horrors of the inquisitorial butcheries and man-hunts of the middle ages. The history of science is the history of a day with a bright morning and a sunny evening, but interrupted at the noontide hour by a total eclipse of common sense and reason. The men that inculcated a belief in the possibility of witchcraft and demoniac possession are responsible for the agonies of the three million human beings that perished in the flames of the stake ; the dogma of total natural depravity guided the arm that aimed its poisoned daggers at the heart of every social, political, or scientific reformer. But the direst of all the evils which made the rule of the miracle-mongers the unhappiest period in the history of this earth was, after all, their total neglect of physical education—the logical outcome of their Nature-hating insanity. Their disciples were assured, in the name of an infallible revelator, that all earthly concernments are vain ; that we can not please God without mortifying our bodies ; that our natural instincts must be suppressed, in order to qualify our souls for the New Jerusalem. The joys of Nature were to be shunned as man-traps of the arch-fiend. Sickness was to be cured by prayer and certain ecclesiastic ceremonies. "Bodily exercise," we are informed, "profited but little." The Olympic games were suppressed by order of a Christian emperor.* The health-code of the Mosaic dispensation was repealed as unessential, and indeed superfluous, in a community of miracle-workers who could defy the laws of Nature with the aid of supernal spirits. Gluttony and besottedness were encouraged by the example of the ministers of that creed. Manly exercises, the festivals of the seasons, mirth, pastimes, and health-giving sports were discouraged as unworthy of a true saint ; the sons of the thaumaturgic church were taught that our natural desires and natural dispositions are wholly evil ; that the study of worldly sciences is vain, and solicitude for the welfare of the body a proof of an unregenerate heart.

To these doctrines we owe the consequences of our countless sins against the physical laws of God ; the many irretrievable losses by the ruin of a former civilization ; the terrible night of the long centuries when science was paralyzed, when industrial progress was lim-

* "A. D." 394.

ited to the invention of new instruments of torture, when the neglect of husbandry changed so many Elysian fields into hopeless deserts. To these doctrines the Latin peoples owe the sickliness and effeminacy which contrast their present generation with the hero-race of antiquity. It is a favorite subterfuge of the Jesuitical apologists to ascribe that degeneracy to climatic influences. A cold climate has not saved the North-China votaries of Buddhism, and would not have saved the North-Europeans against a prolonged influence of Hebrew Buddhism. We must not forget that in Northern Europe the rule of the anti-naturalists did not begin before the end of the seventh century, and never overcame the latent *protestantism* of the Teuton races. In a warmer country than Italy the votaries of the manlier prophet of El Medina have always preserved their physical vigor, and the representative North-African of the present day is the physical superior of his South-European contemporary, while the forefathers of the same African were mere children in the hands of the palæstra-trained Roman warrior.

The physical corruption of the non-Mohammedan inhabitants of Southern Europe and Southern Asia has reached the incurable stage of complacent effeminacy: their indifference to the vices of indolence precludes the possibility of reform. Indifference to physical degradation is, indeed, a symptom of a deep-seated disease. Mental inertness is often but a dormant state of the intellect, a state from which the sleeper may be roused at any moment by the din of war, by the light of a great discovery, by the voice of an inspired poet. Physical indolence is the torpor which precedes the sleep that knows no waking. The civilization of Greece, Dutch art, the science of Bagdad and Cordova, sprang up, like water from the rock of Moses. Can historians point out a single instance of an unmanned people regaining their manhood? The bodily degeneracy of a whole nation dooms it to a hopeless retrogression in prosperity and political power.

The first use we should make of our regained liberty is, therefore, the reëstablishment of those institutions to whose influence the happiest nations of antiquity owed their energy and their physical prowess, their martial and moral heroism, their fortitude in adversity. The physical constitution of man was never intended for the sluggish inactivity of our sedentary and sabbatarian mode of life. In a state of nature, the faculty of voluntary motion distinguishes animals from plants, and our next relatives in the great family of the animal kingdom are the most restlessly active of all warm-blooded creatures. The children of Nature—hunters, shepherds, and nomads—pass their days in out-door labor and out-door sports; physical exercise affords them at once the necessaries of life and the means of recreation, and secures them against all physical ills but wounds and the infirmities of extreme old age. Civilization, i. e., life on the coöperative plan, exempts many individuals from the necessity of supplying their daily wants by daily

physical labor; wealth removes the objective necessity of physical exercise, but the subjective necessity remains; millions of city-dwellers, in their pursuit of artificial luxuries, stint their bodies in the natural means of happiness; they increase their stock of creature-comforts and decrease their capacity for enjoying them; religious and social dogmas pervert their natural instincts; their children are crammed with metaphysics till they forget the physical laws of God.

These evils the inventors of gymnastics managed to counteract, and, before we can hope to recover the Grecian earth-paradise, our system of public education needs an essential and thorough reform. On earth, at least, moral and physical culture should be as inseparable as mind and body; every town school should have an in-door and out-door gymnasium; the same village carpenter who takes a contract for a dozen rustic school-benches should get an order for a horizontal bar and a couple of jumping-boards; every school district should appoint a superintendent of gymnastics; every town a committee of public arenas: cities that can afford to devote a hundred tax-free tabernacles to Hebrew mythology might well spare an acre of ground for Grecian athletics. Plato's Academia and Aristotle's Lyceum were both gymnastic institutions, where the patricians of Athens spent their leisure hours, and often joined in the exercises of the athletes. Our best citizens should emulate their example, and help to eradicate the lingering prejudice against the culture of the manly powers. A field-day, consecrated to Olympic games and the competitive gymnastics of the Turner-hall, should be the grandest yearly festival of a free nation.

In the mean time we must help our children the best way we can by giving them plenty of time for out-door exercise, and providing them, according to our means, with some domestic substitutes for the gymnastic apparatus which, I trust, the next generation will find in every village hall and every town school.*

Children have a natural *penchant* for active exercises. Sloth is one of the vices we should drop from our catalogue of original sins. If a child were banished from the haunts of men, and left to grow up as a wild thing of the woods, he would turn out a self-made gymnast, though perhaps also in the original sense of the term, for gymnasium and gymnastics were derived from a word which means *naked*. Nature seems to deem the development of our limbs a matter of greater importance than their envelopment, and clothes are often, indeed, the first impediment to the free exercise of our motive organs. The regu-

* In 1825 Professor Beck opened in Northampton, Massachusetts, the first American school where gymnastics formed a branch of the regular curriculum. He has found followers, but, considering our progress in other directions, his wheat can not be said to have fallen on a fertile soil. Taking Massachusetts, Ohio, and North Carolina as representative States of their respective sections, it seems that at present (1881) an average of three in every thousand North American schools pays any attention to physical education.

lation dress of the Swedish turners is, in this respect, also the best dress for children—a light jacket, wide trousers and shirts, and broad, low-heeled shoes; in-doors, and in summer-time, shoes and stockings should often be altogether dispensed with. Stephens, the celebrated English trainer, remarked that only men who have their toes perfectly straight will make first-rate runners and wrestlers, and this qualification is nowadays a privilege of country lads who are permitted (or obliged) to run around barefoot all summer. Considering the way we treat our feet, it must often puzzle us what our toes were made for, anyhow; but the antics of a baby in the cradle prove that the human foot is by nature semi-prehensile, and might be developed into a sort of under-hand. Hindoo pickpockets "crib" with their toes, while they stand with folded arms in a crowd, and the Languedoc cork-gatherers ply their trade without a ladder, trusting their lives to the grasping power of their feet. The structural proportions of a new-born child also show a comparatively unimportant difference in the size of the lower and upper extremities; but, in the course of the first twelve years, this difference increases from 2 : 5 to 1 : 3, and often as much as 1 : 4; in other words, while an infant's two arms weigh nearly as much as one of its legs, the arm-weight of a schoolboy is often only one fourth of his leg-weight. The reason is that, of all the active exercise a child gets, nine tenths fall generally to the share of its lower extremities. A little child can not stand erect; the task of supporting the weight of the whole body on two feet exceeds its untried strength. But in local progression we do more: taking a step means to support and propel, or even lift, the whole body by means of the foot remaining on the ground. In running up and down stairs, to school and back, and here and there about the house, the legs of the laziest schoolboy perform that feat about eight thousand times a day. What have his arms done in the mean while? Carried a chair across the room, perhaps, or elevated so and so many spoonfuls of hash from the plate to a place six inches farther up, besides supporting the weight of three or four ounces of clothing. To equalize this difference should therefore be the primary object of physical culture, for the harmonious structure of all its parts is an essential condition of a perfectly developed body. No malformation is more common in city recruits than a narrow chest. Besides spear-throwing, of which I shall speak further on, any exercise promoting the development of the shoulder-muscles will tend to expand the chest, and thus remove the chief predisposing cause of consumption. In a climate where the first four years of a child's life have to be passed mostly in-doors, a special room of a spacious house or a corner reservation of a small nursery should be set apart for arm-exercises—hurling, swinging, and lifting. The arrangements for the propulsive part of the good work need not go beyond an old bolster and a cushion-target, but the *grapple-swing* should be both safe and handy—a pair of swinging-rings suspended

at a height of about four feet from the floor above a stratum of old quilts and carpets. In London, and in some of our Northeastern cities, *health-lifts* for children can now be got very cheap ; weighted buckets, however, or sand-bags with strap-handles, will serve nearly the same purpose ; and smaller bags of that kind may be used for various dumb-bell exercises. A plurality of young gymnasts can vary the programme by throwing such bags to each other and catching them with outstretched arms. In a suitable locality I would add a knotted rope, fastened to the ceiling by means of a screw-hook, and hanging down in a single or double chain, which children soon learn to climb by the hand-over-hand process, thus strengthening the triceps and flexor muscles, to whose development the quadrumana owe their peculiar arm-power. A full-grown man who has passed his life behind the counter will find it rather difficult to raise his body by the contraction of his arm-muscles, but, unless Darwin is right, Heaven must have intended us to pursue the culture of our higher virtues in the tree-tops, after the manner of the gymnosophists, for a young child acquires all climbing tricks with a quite amazing facility—much readier, in fact, than the art of biped progression, whose chief difficulty consists, perhaps, in the necessity of preserving the equilibrium. The knots should be far enough apart to tempt an enterprising climber to dispense with their use now and then and rely on the power of his grasp by seizing the rope at the interspaces ; and this exercise should be especially encouraged, for the strength and suppleness of the wrist-joint will considerably facilitate the attainment of "polytechnic skill," as modern Jacks-of-all-trades begin to call their versatile handiness. Nay, the Rev. Salzmann holds that the ancient practice of hand-shaking was originally suggested by the wish to ascertain the wrist-power and consequent wrestling capacity of a stranger. As to the rest, negative precautions will generally suffice for the first three or four years. Diminish the danger of a fall by padding the floor of your nursery-gymnasium, and the restless mobility of your pupils will generally save you the trouble of initiating them in the rudiments of hopping and tumbling. But make it a rule with all hired or amateur nursery-maids that the children must not be carried more than is absolutely necessary.

In long winters it can do no harm, now and then, to let the youngsters turn the hall into a race-course ; but, with the first warm weather, the arena should be removed to the next playground—a garden-lane, or a vacant lot without rubbish-heaps, if the Park Commissioners are too proscriptive. In its general invigorating effect on the organic system, running surpasses every other kind of exercise. Among the contests of the palæstra it ranked above wrestling and boxing ; for more than two hundred years the Olympic games consisted, indeed, exclusively of foot-races, and the chronological era of Greece dated from the year when the Elean Corœbus defeated his Peloponnesian competi-

tors in the long-distance match. The swift-footedness of Achilles is mentioned as often as his name occurs in the "Iliad"; and, according to the Scandinavian Saga, the champions of Jötunheim distanced even the henchman of Thor in a foot-race. Next to a smooth and perfectly level lawn, a firm beach is the best race-course, and, after a warm day, it is a luxury to the martyred feet of a city boy to tread the cool sand with his naked soles. Fast running is, on the whole, a more valuable accomplishment than long walking, for no one knows when he may owe his life, and more than his life, to the ability of outrunning a pursuer or a fugitive scoundrel; but walking and trotting matches against time will help to cure our children of that miserable snail-pace which has come to be the fashion of every public promenade. Reduced to a funeral-march, the "regulation walk" loses half its value—the hygienic value of the only kind of out-door exercise which the children of the upper ten or twenty can count upon. Who could wish a prettier sight than a bevy of schoolgirls, flitting by with fluttering flounces, like dancers keeping step to a merry tune? If mothers knew all the charms of *animated* beauty, they would not think it "more becoming" to turn their children into tortoises. Nor would they fear that they would "run themselves into a consumption," if they knew what real running means, and what the motive organs of a human being are capable of. Mexico has ceased to be a *terra incognita* to Yankee tourists, and most visitors to the upland cities will remember the army of hucksters and poulterers who every forenoon turn the main plaza into an agricultural fair. If you will take a morning walk on one of the sand-roads that diverge from the south gate of Puebla, you may see those hucksters coming in *at a trot*, girls in their teens many of them, and loaded with sacks and baskets; and upon inquiry you will learn that most of them come from the valley of Tehuacan, from a distance of ten or twelve English miles. The *zagal*, or post-boy of a Spanish mail-coach, carries nothing but a light whip, but he has not only to keep pace with a team of galloping horses for hour after hour, but has to run zigzag, adjusting a strap here, picking up a handkerchief there, and frequently entertains the travelers with a series of hand-springs, in order to earn an extra *medio* or two—not to mention the Grecian *hemerodromes*, who could distance a horse on the long run, and had often to cross rivers and lakes on their bee-line routes.

An excellent system of training was that of the old Turkish Jenidji-begs, or drill-masters of the Janizary cadets, who made young boys practice lance-throwing with a spear that *exceeded* the common javelin both in size and weight—"because, after they had become proficient in the use of such a heavy implement, the army-spear would be a mere feather in their hands." On the same principle the knee-muscles may be strengthened by a simple manœuvre without the use of any apparatus. Bend the left leg in a right angle, extending the right leg horizontally, and lower the body till your right heel nearly

touches the ground. Now rise by straightening the left leg, with the right still extended horizontally, and without letting your hands or your right heel touch the ground. Then squat down as before, extend the left leg this time and rise on the right, and so on until the weight of the body has been raised twenty or thirty times by the effort of either knee-joint without the aid of the other. A moderate proficiency in this exercise will enable girls and city boys to walk up-hill for hours with the ease of a Tyrolese goat-herd.

In classifying gymnastics after the degree of their usefulness, a prominent place should be assigned to leaping, especially high leaping, an exercise which imparts a powerful stimulus to the digestive organs, and, combined with the shock of the descent, exerts an invigorating influence on the nervous system in general. The leaping-gauge of the Turner-hall consists of two upright posts with pegs and a cord stretched from post to post. Every peg is marked with a figure indicating the number of inches from the ground, and by raising or lowering the cord each gymnast can measure his jumping capacity and keep tally of his score in a certain number of leaps. Competition imparts to this sport an incentive which may be put to as good account in gymnastics as in mental exercises, and is certainly preferable to the only other method of stimulating the zeal of young pupils. Personal ambition, according to the ethics of a certain class of pedagogues, is inconsistent with the spirit of true Christian humility, and should be quelled rather than fomented ; in dealing with unruly youngsters they have consequently to resort to the only alternative, slavish fear, enforced by punishments and espionage. For the nonce, that system answers its purpose quite as well as the emulation-method ; as to future results, your choice must depend upon the main question of modern education, Are we to form men or canting sneaks ?

A quadruped has an evident advantage over a biped jumper, but practice will do wonders. Leonardo da Vinci often astounded his visitors by jumping to the ceiling and knocking his feet against the bells of a glass chandelier, and a private soldier of Vandamme's cuirassiers even leaped over the tutelar deity of a brass fountain on the Frankfort market-square. But the champion jumper of modern times was Joe Ireland, a native of Beverley in Yorkshire. In his eighteenth year, "without any assistance, trick, or deception," he leaped over nine horses standing side by side and a man seated on the middle horse. He could clear a string held fourteen feet high, and once kicked a bladder hanging sixteen feet from the ground.* In horizontal leaps our turners can not beat the record of antiquity : a Spartan once cleared fifty-two feet, and a native of Crotona even fifty-five. Nor would any modern filibusters be likely to emulate the trick of the Teuton freebooters who crossed the Alps during the consulate of Caius Marius : Finding the Roman battle-front inexpugnable, they at-

* Strutt's "Plays and Pastimes," p. 176.

tempted to force the fight by vaulting with the aid of their *framæ* or leaping-poles over a triple row of mail-clad spearmen.

Hurling is the gymnastic specific for pulmonary complaints; and the best possible exercise for so many hectic and narrow-chested boys of our larger cities would be the game of *Ger-werfen*, as the turners call it—spear-throwing at a fixed or movable mark. It is a most diverting sport after a week's practice has hardened the flexor muscles against the shock of propelling the larger spears. The missile is a lance of some tough wood (ash and hickory preferred), about ten feet long and one and a half inch in diameter, terminating in a blunt iron knob to steady the throw and keep the wood from splintering. A heavy post with a movable top-piece (the "Ger-block") forms the target, the head-shaped top being secured by means of a stout cramp-hinge that permits it to turn over, but not to fall down—distance, all the way from ten to forty paces. Grasp the spear near the middle, raise it to the height of your ear, plant the left foot firmly on the ground, the right knee slightly bent, fix your eye on the target, lean back and let drive. If you hit the log squarely in the center or a trifle higher up, it will topple over, but, still hanging by the cramp-hinge, can be quickly adjusted for the next thrower. A feeble hit will not stir the ponderous Ger-block; the spear has to impinge with the force of a sixty-pound blow, so that a successful throw is also an athletic triumph. The German Ger-throwers are generally lads after the heart of Charles Reade—ambidexterous boys, whose either-handed strength and skill illustrate the fact that the antiquity of a prejudice proves nothing in its favor. As the least vacillation in the act of throwing would derange the aim, this exercise imparts a perfect command over the balance of the body, besides improving the faculty of measuring distances by the eye. It is, indeed, surprising how soon gymnastics of this sort will impart an easy deportment and graceful manners even to boys in their lubber-years—"*Nur aus vollendeter Kraft strahlet die Anmuth hervor*," as Goethe explains it: "The highest grace is the outcome of consummate strength."

Climbing, too, calls into action nearly every muscle of the human body, and should be encouraged, though at the expense of a pair of summer pants or summer birds, as the possibility of accidents is more than outweighed by the sure gain in physical self-reliance. There is a deep truth in the apparent paradox that it is the best plan *not* to avoid dangers and difficulties that can be mastered. In the voluntary risks of the gymnasium the athlete pays an insurance policy against future dangers. In a man's life there will always come moments when the woe and weal of years depend on firm nerves and a strong hand, and such moments prove the value of a system of training which teaches children to treat danger as a mechanical problem. The operation of the same cause may be traced in the *realistic* influence which the culture of the manly powers generally exerts on the human

mind. Having learned to rely on their personal strength and judgment under circumstances where shams are peculiarly unavailing, gymnasts will generally be men of self-help ; practical, rather apt to believe in the competence of human reason and human virtue and to question the utility of a pious fraud.

On rainy days an in-door gymnasium is as useful as a private library. Where wood is cheap, the aggregate cost of the following apparatus need not exceed fifty dollars : 1. A spring-board and leaping-gauge ; 2. An inclined ladder ; 3. A horizontal bar ; 4. Swinging-rings ; 5. A vaulting-horse (rough hewed) ; 6. A chest-expander (elastic band with handles) ; and, 7. A pair of Indian clubs. Buckets filled with shot or pig-iron will do for a health-lift. With this simple apparatus an infinite variety of health-giving exercises may be performed without much risk ; on the horizontal bar alone Jahn and Salzmann enumerate not less than one hundred and twenty different movements, most of which have proved very useful in correcting special malformations. For general hygienic purposes a much smaller number will be sufficient, especially where the neighborhood affords an opportunity for occasional out-door sports ; for an in-door gymnasium is, after all, only a preparatory school, or at best a substitute for the palæstra of Nature—the woods, the seashore, and the cliffs of a rocky mountain-range. But in large cities even the poorest ought to procure a few gymnastic implements ; no dyspeptic should be without a spring-board and some sort of health-lift.

The victims of asthma would throw a considerable quantity of physic to the dogs if they knew the value of a mechanical specific—a few minutes' exercise with the *balance-stick*, an apparatus which any man can manufacture in half an hour, and at an expense representing the value of an old broom-stick and a yard of copper wire. Take a straight stick, about six feet long and one inch in diameter, and mark it from end to end with deep notches at regular intervals, say two inches apart, with smaller subdivisions, as on the beam of a lever-balance. Then get a ten-pound lump of pig-iron, or a large stone, and gird it with a piece of stout wire, so as to let one end of the wire project in the form of a hook. The exercise consists in grasping the stick at one end, stretching out arm and stick horizontally like a rapier at a home-thrust ; then draw your arm back, still keeping the stick rigidly horizontal, make your hand touch your chin, thrust it out again, draw back, and so on, till the forearm moves rapidly on a steady fulcrum. Next *load* the stick—i. e., hook the stone to one of the notches ; every inch farther out will increase the weight by several pounds. Hook it to one of the middle notches, and try to move your arm as before. It will be hard work now to keep the stick horizontal ; even a strong man will find that the effort reacts powerfully on his lungs : he will puff as if the respiratory engine were working under high pressure. On the same principle, the lungs of a half-drowned man may be set awork by mov-

ing the arms up and down like pump-handles. But the weighted stick, bearing against the sinews of the forearm, still increases this effect, and overcomes the stricture of the asthmatic spasm, as the movement of the loose arms relieves the torpor of the drowning-asphyxia. With the aid of this mechanical *palliative* (for death is the only radical asthma-cure) the distress of the spasm can be relieved before the actual dyspnœa or breathlessness has begun, and, after ten or twelve resolute efforts, the feeling of oppression will generally subside and the lungs resume their work as if nothing had happened. Daily exercise with the balance-stick is sure to diminish the frequency of the attacks, and, if begun in time, would probably cure children from an hereditary tendency of this sort. Two years ago I sent this receipt to an asthma-martyr whom the narcotic-vapor cure did not save from a weekly repetition of all the horrors of strangulation. He has now lengthened the period of his complaint from a week to an average of forty days, and assured me that even a few minutes' exercise with a six-pound weight has saved him many a sleepless night.

Lifting and carrying weights was a favorite exercise with the ancient athletes, and our modern rustics are still very apt to estimate a man's strength by his lifting capacity. The "best man" of a Yorkshire parish is generally he who can shoulder the heaviest bag and carry it farthest and with the firmest step. Feats of this sort require certainly a sound constitution in every way; weak lungs, especially, are sure to tell, but the main strain bears upon the thighs and the small of the back: a good lifter has to be a strong-boned man, and will generally make a good wrestler and rider. Weak-backed children will, therefore, derive much benefit from the various exercises with hand-weights and lifting-straps, and, indeed, from any labor involving the addition of an extra burden to the natural weight of the body. Heavy lifts require some precaution against strains—a waist-belt, and unflinching steadiness in rising from a stooping position; but it should be remembered that *rupture* (hernia)—generally ascribed to the effects of overlifts—results more frequently from the shock of a fall, and a predisposing defect of the abdominal teguments. The history of the lifting-cure records not a single instance of a rupture having *originated* from the often enormous feats of professional gymnasts, or the more dangerous efforts of enthusiastic beginners. As a general rule, it may be relied upon that a perfectly sound child can not overlift himself before his strength gives way—I mean, before the yielding of his muscles and sinews simply compels him to drop the burden. Here, too, the achievements of ancient and modern Samsons illustrate the tenacity of the human frame and its marvelous capacity for development. The credibility of the Gaza story depends somewhat upon the size of those city gates; but there is no doubt that Thomas Topham, of Surrey, once shouldered a sentry-box containing a stove, a bench, and a sleeping watchman, and carried his burden to a suburban cemetery.

Dr. Winship, of Boston, lifted twenty-nine hundred pounds with the aid of shoulder-straps; and, unless the historians of Magna Græcia were afflicted with an abnormal development of the myth-making faculty, it would seem that their countryman Milo carried a bull-calf around the arena, and thus carried it every day till he could tote a full-grown steer. If the story is even half true, we need not wonder that Milo's powers as a wrestler put a temporary stop to that sport as a branch of the Olympian games, since "no man or god durst accept his challenge."

Wrestling is still the chief accomplishment of the Swiss village champions, and would be the favorite pastime of our rural districts if it had not been kept down by our sickly prejudice against all rough-and-ready sports. Fifteen centuries ago the Olympic games were abolished by the decree of a Christian emperor; the moralists of Old England have tabooed pugilism; our sabbatarians now include even wrestling among the "blackguard sports"; and Frederick Gerstaecker predicts that the American Inquisition of a future century will suppress skating and ball-playing "as giving an undue ascendancy to the animal energies over the moral part of our nature." For such a century's sake we should hope that the Patagonian savages will prove unconquerable, for a year's *life* among healthy beasts would be a blessed relief from a long sojourn in the land of an unmanned nation.

But I trust that the propaganda of the Turnbund will save us from such a fate. What a stimulus it would give to manly sports and manly virtues, nay, to the physical regeneration of the human race, if we could made their yearly assembly a national festival! The river-meadows of Chattanooga, or the mountain amphitheatre near Huntsville, Alabama, would make a first-class Olympia, and our Indian summer would be a ready-made "weather-truce," without an expensive burnt-offering to the sun. Olives, it is true, do not flourish on our soil; our mercenary souls need other inducements; but the rent of reserved seats and camp-tents would enable us to gild the crowns of the several victors. Imagine the athletes of every village training for those prizes—thousands of boy-topers turning gymnasts, ward delegates running for something besides office, and the members of a Young Men's Association seeking paradise on this side of the grave!

With the decadence of athletic sports, games of skill come generally into favor; hence, perhaps, the revival of archery in the United States, and the pandemic spread of certain amusements which are properly ladies' plays. Riding has gone almost out of fashion, though few sportsmen will gainsay me if I assert that a day in the saddle is worth a week of other *sedentary* pursuits. A Mexican boy would part as soon with an arm as with his horse, and I never saw a finer picture of exultant health than a cavalcade of *muchachos* dashing out into the prairie at full speed, whooping and cheering, though perhaps on their way to school or to a *funcion* of some national saint. The deportment

of such little equestrians is distinguished by a certain chivalrous frankness, and the word *chivalry* itself, as well as the German *Ritter* ("caballero"), were originally derived from horse-riding. The rider's management of his nag may tend to develop the domineering, the princely traits of human nature, though probably at the expense of a humbler virtue or two; in Spanish America, at least, the experience of Indian agents and Indian school-teachers has shown that the pedestrian red-skins are generally more manageable than their mounted *compadres.*

The lovers of aquatic sports may combine a useful accomplishment with the best relief from the midsummer martyrdom of our large cities. The art of swimming adds as much to the pleasure of bathing as it does to its healthfulness; but it has often puzzled me that with the human animal that should be an art which is a natural faculty of *all* other mammals. Dr. Andersson's theory is probably the right solution of the riddle. He noticed that to the young negroes of Sierra Leone swimming comes almost as natural as walking (in which attainment they are also rather precocious), and he concludes that the disability of a white man's child arises chiefly from a general want of vigor. Our mobile arms and paddle-like hands are better swimming implements than the drumstick legs of a dog; but our muscular debility more than counteracts these advantages. The limbs of a child are swathed, confined in tight clothes, kept year after year in compulsive inactivity, till, in proportion to its size, the nursling of civilization is the weakliest of living creatures. After exercise has developed the defective muscles, a swimmer can hardly understand how he could ever be in dread of deep water, swimming seems so easy; the faculty of floating, as it appears to him, is an inalienable attribute of a human creature, requiring neither art nor anything like a great effort except in swimming against the stream; he would undertake to study, read, or dream in a calm sea, and let the body take care of itself. The Marquesas-Islanders witnessed the struggles of a sinking English sailor with mute astonishment, and neglected to help him, utterly incapable of realizing the fact that a full-grown man could be in danger of drowning.

In the sixteen provinces of the Roman Empire every larger town had a free bath or two, and our entire neglect of this branch of public hygiene is certainly the ugliest feature of our boasted civilization; but our children at least might make shift with the natural bathing facilities which can be reached by a short excursion beyond the precincts of all but the unluckiest cities. A cool bath at the end of a sweltering day can be delightful enough to reconcile a poor city slave to his misery; the sensation of floating along with the rhythm of a dancing current admits no comparison with any *terra firma* pleasure, and awakens instincts of the human soul which may date from the life of our marine ancestors in the days of the Devonian fore-world. But such enjoyments are the privilege of the aquatic gymnast, and no swimmer should deem it below his dignity to imitate the example of the elder

Cato, who taught his sons to dive and traverse rapid rivers. I know that a swimming-school is not always a favorite resort of a young child; weakly youngsters are apt to prefer a sponge-bath; but I agree with the Baptists, that immersion alone will save us. The way of the beginner is hard, but the reward is worth the price. No boy who has learned to "tread water" or to "take a header" from a high bank would exchange the wild joy of his sport for all the taffy of a tame Sunday-school picnic. And it is a great mistake to suppose that hardy habits would harden the character; on the contrary, the bravest lad of a parish can generally be known by his cheerfulness and his frank good-nature, and in after-years will be apt to meet the billows of life with a joyous zeal rather than with a shivering "resignation." I am often tempted to quote the remark of a French training-ship surgeon, of blunt speech, but with a sharp eye for the character-traits of his young countrymen: "If I had my own way," said he, "every boy in the marine should serve an apprenticeship in the rigging, and learn to rough it, before he gets a soft berth. The lads that have grown up before the mast make the best men in every sense of the word, brave, honest fellows most of them; while the cabin-boys, who have been pampered with titbits and soft jobs generally, turn out" (I won't risk a literal translation) "prevaricating puppies," or words to that effect.

Per aspera ad astra, and a very important branch of gymnastic education might be included under the head of hard work or voluntary labor. Labor with a practical purpose is not only more visibly useful but more agreeable than mere crank-work at the horizontal bar, and it is sometimes advisable to beguile ourselves into a strenuous and long-continued physical effort. For what we call vice or evil propensities is often nothing but misdirected energy, vital force exploding in the wrong direction for want of a better outlet. The sensible remedy is not to anathematize such energies, but to let our muscular system absorb them by engaging in some entertaining out-door business requiring a good deal of heavy work. In summer-time there will be no lack of such jobs: interest your *enfant terrible* in horticulture; make him transplant shade-trees and dig ditches; send him to the gravel-pit, and let him fill his wheelbarrow with sand and his pockets with geological specimens. Or enlist his constructiveness: set him to build a garden-wall, and quarry his own building-material in the next ravine. During the progress of the good work the hours will vanish magically, and so will the evil propensities. Novel-reading girls can generally be cured with a butterfly-catcher; entomology and sentimentalism are not concomitant manias.

It has often been observed as a curious phenomenon that the vilest young hoodlums are found in the middle-sized towns. I believe I could suggest an explanation: In very large cities, as well as in the woods and mountains, they find something else to do. A New York street Arab is often addicted to sharp practice, but not often to degrading

vices. He can't afford to be vicious: sensuality weakens; physical vigor is a stock-in-trade; the fierceness of competition compels him to use every advantage. For the same reason a training oarsman is generally an exemplar of all manly virtues; to him experience has demonstrated the *temporal* disadvantages of vice, an argument whose cogency somehow conquers objections that resist the most eloquent *argumenta ad fidem*. Moreover, such virtues with a business purpose are liable to become habits. If we could keep a record of the longevity of our university crews, we would probably find that the victors outlive the often vanquished; the champions of Olympia (with the exception of the cestus-fighters) generally attained to a good old age.

It is, indeed, a pity that oar-contests should be confined to our lake-shore cities and a few college towns; as an athletic exercise rowing is out and out superior to ball-playing and skating, and a sovereign remedy for many disorders of the respiratory organs. Venice has all the topographical characteristics of a consumption town—stagnant lagoons, damp buildings, dark and narrow streets—and yet the lower classes of her population are remarkably free from pulmonary affections—they have a gondolier in nearly every family. The watermen of the Thames, too, are generally long-lived, in spite of being so much exposed to wet and cold. If I had to limit a child to two kinds of out-door exercises, I would choose running and rowing: the one does for the legs and the stomach what the other does for the arms and the lungs.

It is said that Cyrus advised his countrymen "never to eat but after labor," and, as a general rule, the best time for out-door exercise is certainly rather before than after meals; but gymnastics of the heroic kind may induce a degree of fatigue which decreases the appetite instead of stimulating it, and in summer it is by far the best plan to take the last meal in the afternoon, and postpone athletic sports to the cooler hours of the evening. In moonlit nights, out-door games may be continued for several hours after sunset. A nearly infallible receipt for pleasant dreams is a light supper, followed by competitive gymnastics in the presence of (somebody's) sisters and cousins. In stress of circumstances, though, the fair witnesses can be dispensed with. Even an in-door gymnasium will answer the main purpose; it is the relaxation of the strained sinews which makes rest sweet; the soul seems to revel in a conscious sense of health to come. It is a fact that a man may be "too tired to sleep"; but that sort of insomnia is always a sign of general debility. Our latter-day sports are not likely to hurt a healthy boy through excess of exercise. We hear of people having "killed themselves with hard work"; but, if their habits were otherwise correct and their diet not altogether insufficient, they must have worked hard indeed, and with *suicidal intent*, I am tempted to say, as we have no single word for *Lebensmüde*—the reckless contempt of life which can make men deaf to the voice of their physical conscience.

The Manitoba lumbermen ply their hard trade cheerfully for ten hours a day for months together, and the pastoral nomads of the Caspian steppes often keep their boys in the saddle for two days and two nights.

It can do no harm to let girls join in the athletic sports of their brothers ; though in their case an harmonious structural development is of more importance than the attainment of muscular strength. Their natural vocation exempts them from the necessity of engaging in violent exercises, and the experience of every nation has confirmed the somewhat obscure biological fact that a child's bodily constitution depends chiefly on that of his paternal relatives. A weakling can never become the father of robust children ; while a delicate but otherwise healthy woman may give birth to an infant Hercules. But, for boys, the most thorough physical education is the best ; a child can never be too weakly to profit by gymnastic exercises. If the culture of the bodily faculties were made a regular branch of public education, robust strength would be the rule and debility the rare exception. The puniness and sickliness of the vast plurality of our city boys are indeed something altogether abnormal. If our primogenitor (as we have no reason to doubt) surpassed the other primates of the animal kingdom in strength as much as he still exceeds them in size, he must have been fully able to hold his own against any beast of prey. Dr. Clarke Abel's undoubtedly authentic description of an orang-outang hunt near Rangoon, on the northwest coast of Sumatra, reads like an episode from the "Lay of the Nibelungen," rather than like the account of a conscientious and scientific observer. With five bullets in his body, the hairy half-man still leaped from tree to tree with the agility of a panther, survived the fall of the last tree, and, though crippled by a shower of blows, snatched a spear from the hands of his chief assailant and broke it like a rotten stick. On his campaign against a horde of northern barbarians, one of Trajan's generals attempted to scare, or at least to astonish, the natives by shipping a troop of lions across the Danube. But the children of Nature declined to marvel : "They mistook them for dogs," says the historian, "and knocked their brains out." Even after the middle of the fourteenth century the levy of a small German burgh could turn out more athletes than the combined armies of the present empire ; the Margrave of Nuremberg could at any time muster ten thousand men, every one of whom was able to wear and use accoutrements that would crush a so-called strong man of the present day. In the armories of Vienna, Brunswick, and Strasburg there are coats of mail which a modern porter would hesitate to shoulder without the assistance of a comrade.

And yet these mediæval Samsons were the exclusive product of the drill-ground ; physical vigor was not valued as the foundation of health and happiness, but rather as a means of military efficiency ; the guardians of public education merely connived at such things ; and, when

the invention of gunpowder diminished the importance of personal prowess, our anti-natural dogmas accomplished their tendency in the rapid physical corruption of their devotees. The dull and gloomy slavery of the monasteries was transferred to the management of all educational institutions; for several centuries the bodily rights of the poor convent-pupils were not only disregarded but willfully depreciated. Educational influences became the chief cause of physical degeneracy, and the superficialness of our reformatory measures proves that we have not yet recognized the root of the evil.

But the voice of Nature has repeated its protest in the yearnings of every new generation. Our children still long for out-door life, for active exercise, for the free development of every bodily faculty; and, if we cease to suppress those instincts, the regenerative tendency of Nature will soon assert itself, and the time may come when man will be once more the physical as well as mental superior of his fellow-creatures.

THE MINERAL SPRINGS OF SARATOGA.*

By CHARLES F. FISH.

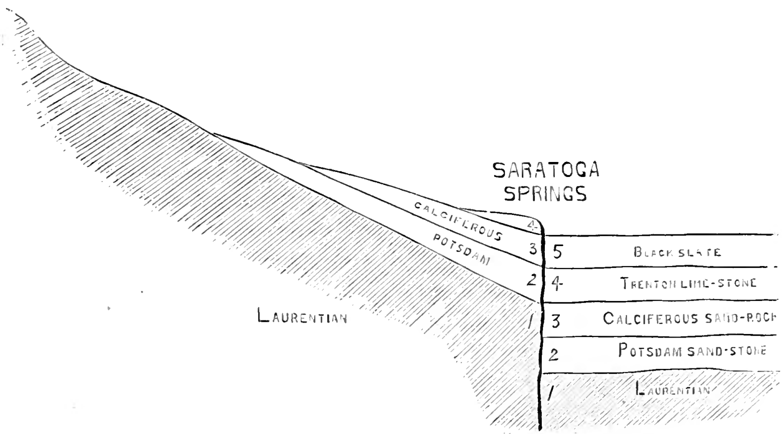
ASIDE from the rich field for scientific research that the mineral springs of Saratoga present to the student of natural phenomena, the majority of the members of this Association are undoubtedly interested to a greater or less extent in a product that forms, with many, a large, important, and increasing item of trade, there being probably no one class of mineral waters of domestic production, or from any one locality, that are used to so great an extent as those from Saratoga Springs. On this account, as well as for the reason that our Association holds its twenty-eighth annual meeting in this village, where an opportunity is afforded of personally inspecting the source of supply of these waters, it will, perhaps, not prove uninteresting to present some facts regarding an article that has contributed so largely to the prosperity of Saratoga in the past, and upon which its future interests to a great degree depend.

Saratoga Springs is an incorporated village, having a resident population of about ten thousand, which is largely augmented during the summer season. It has an altitude of three hundred and five feet above tide-water, is one hundred and eighty-eight miles north of New York City, on the line of the Rensselaer and Saratoga Railroad, and is situated in and on either side of a valley extending from northeast to southwest. Prior to 1767 little or nothing was known by the whites regarding the waters of this section. In August of that year Sir

* Read at the Saratoga meeting of the American Pharmaceutical Association, September 16, 1880.

William Johnson was conveyed from Schenectady to this locality on a litter, by some of the Indian braves of the Mohawk tribe, by whom he was evidently much loved and esteemed. It is highly probable that the High Rock was the only spring known to the Indians, and that Sir William was the first white man that ever visited it. In the long interval that has elapsed since the location of the High Rock was revealed, the number of springs developed has been very largely increased. With regard to the origin of these springs there are two theories advanced, both of which have able and zealous advocates; but, before presenting the claims of either of them to your consideration, it will be necessary to describe the geology of this vicinity, in order that they may be more fully comprehended. All of the rocks of this county are members of the oldest systems of geological formation, and are both metamorphic and sedimentary in their character; the granitic or Laurentian is of archæan origin, the remaining strata having been deposited during the Lower Silurian age. The accompanying map represents a transverse section of these formations, extending from the eastern portion to the higher altitudes located in a northwesterly direction from this village. The underlying rocks comprise first, the Laurentian; second, the Potsdam sandstone; third, the calciferous sand-rock; fourth, the Trenton limestone; and, fifth, the Utica, or black slate. At a very remote period of the past, the rocks comprising these various strata were subjected to some powerful natural force, which resulted in their fracture, dislocation, and the gradual upheaval of a large portion of them, producing at the point of disruption what is known to geologists as a fault. The position occupied by

Fig. 1.



the various strata is shown in Fig. 1: No. 1 indicates the Laurentian, the oldest of those belonging to the metamorphic system; No. 2, the Potsdam sandstone; No. 3, the calciferous sand-rock; No. 4, the

Trenton limestone; and, No. 5, the Utica or black slate; the fault, or break-off, is indicated by the heavy black vertical line, in immediate proximity to which the village of Saratoga Springs is situated. For the reason that the black slate has been entirely eroded from that portion of the village immediately west of the fault, and the Trenton limestone nearly so, none of the former and but a thin stratum of the latter formation is represented on the accompanying chart. You will observe that both the dislocation and upheaval of these various strata are strongly marked at the fault, for, while that portion lying to the east remains *in situ*, that to the west is tilted up to such an extent that the dip of some of the strata is as great as twenty degrees. You will also notice that the Laurentian rock on the west side of the fault, occupying the position designated as No. 1 on the cut, as well as the superimposed strata, viz., Nos. 2, 3, and 4, are not in perfect opposition with formations of like character on the east side, the Potsdam sandstone lying opposite to the Trenton limestone, the calciferous sand-rock lying in conjunction with the black slate, while the Trenton limestone on the west occupies a position above the black slate on the east. The consideration of this phenomenon naturally suggests an explanation, but so far as is known there is but one theory relative to the subject, it being universally conceded that the force that produced this disruption was due to volcanic agency.

At distances varying from two to twelve miles in a westerly direction ranges of hills and mountains are encountered, presenting altitudes several hundred feet above this village. In addition to the enormous area of water-shed that these elevated regions afford, they possess many ponds and lakes, some of which are of no insignificant size. The surface-streams that drain this section flow toward the east, and, as the various strata dip in the same direction, the tendency of the subterranean drainage must be toward the same point of the compass.

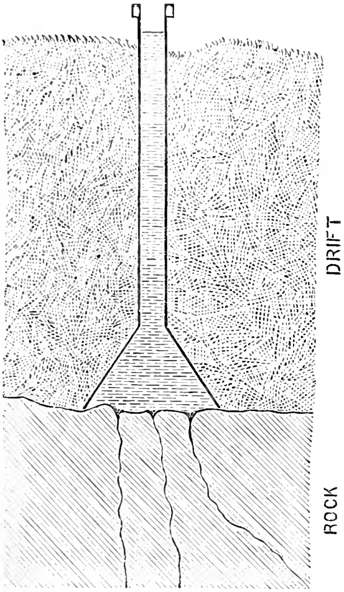
The advocates of the first of the theories regarding the origin of the mineral springs of Saratoga, recognizing the disintegrating and solvent action of the water under its various forms of rain, snow, and ice, claim that they are produced by the process of displacement or percolation, holding that, when water falls upon the elevated regions just described, a portion of it gradually permeates the soil and the various strata of the underlying rocks, dissolving and carrying with it in its downward flow the various constituents of which the rocks are composed, and that these are decomposed by their reaction on each other, and new compounds are formed with the evolution of carbonic-acid gas, that this is dissolved by the water, which becomes highly impregnated with it, increasing its solvent properties to a great extent, enabling it to accumulate basic matter in its flow, which continues downward and eastward, until the fault is reached, where an opportunity is afforded for it to escape from the rocks and rise to the

surface through the various crevices with which the fault is environed, or make its escape through subterranean channels to unknown outlets ; in either event the result is due to the simple law of gravitation and hydrostatic pressure, the bodies of water stored in the lakes, ponds, and rocks of the higher altitudes furnishing the necessary causes to produce this result.

To substantiate this theory, attention is called to the close resemblance existing between the leading chemical constituents of these waters and sea-water ; it being claimed that the mineral matter of the rocks, through which the waters percolate, was deposited from very ancient oceans, the existence of which was contemporaneous with the period that embraces the deposit of the geological formations to which the various strata of this region belong. Those that advocate the second theory with regard to their origin agree with the adherents of the theory that has just been presented, in recognizing the elevated section situated west of the village and the fresh water that flows from it through the various strata as being the prime source from which these mineral springs are derived, but decline to accept the theory that their constituents are obtained by the percolation of the fresh water through the rocks, maintaining that the water remains virtually unimpregnated until the fault is reached, and that it is at this point that it becomes charged with both its mineral and gaseous constituents ; claiming that, inasmuch as the fault extends downward to an unknown depth, and to the internal fires of the earth, and that the substances with which these springs are impregnated closely resemble those evolved in a gaseous state from volcanoes, that the mineral constituents of these waters are obtained from the heated interior by the process of sublimation and subsequent absorption, while the gases are also derived from the same source in a free state. About the year 1827 the late Dr. Steele, of this village, formed a stock company to bore for salt, maintaining that the chloride of sodium contained in these springs was derived from underlying beds or reservoirs, and that it could be obtained by boring, and made a source of profit to those that would engage in the enterprise. Accordingly, operations were commenced several hundred feet west of the fault, and an artesian well, three inches in diameter and one hundred and eighteen feet in depth, was sunk in the underlying rock ; but, inasmuch as none but fresh water was obtained, the scheme was abandoned ; other wells bearing about the same relative position to the fault as this one have been secured at various times, but always with the same result. From the fact that the temperature of these wells and that of the mineral springs just east of them is said to be identical, and that they are, like the latter, never affected by surface-drainage, it is claimed that both have a common origin, and those that advocate the theory of sublimation claim that, if the waters are fresh at the site of these fresh-water wells, it is impossible for them to become mineral in their

character by the short passage through the rocks that intervene between them and the fault; and hence they insist that the theory of percolation is untenable. There are two methods of securing the mineral springs of this locality: the first is shown at Fig. 2, and consists in excavating to an extent of twenty or thirty feet square surrounding the spot where indications of mineral water are observed, and extending downward through the various drift-formations until the underlying rock is reached. As the work progresses, a shaft or crib is sunk in order to prevent the sides from caving in; and, to obviate the collection of water and carbonic-acid gas at the bottom of the shaft, powerful steam-pumps are kept in constant operation, which effectually drain the excavation. After reaching the fissured crevices in the rock that environ the fault, and through which the water issues, a pyramidal wooden hopper, about one foot square at the apex, and two or three feet at the base, is placed on the rock directly over that portion of the crevice from which the water issues most abundantly, its position being firmly secured by packing clay tightly around its exterior. As rapidly as the work of filling in the shaft progresses, a wooden tube, about one foot square, is accurately adjusted to the hopper, from which the water gradually rises until it reaches the outlet at or near the top. The depth at which the rock is located from the surface varies from fifteen to fifty-seven feet. The flow of water from springs secured in this manner averages from thirty to one hundred and twenty gallons an hour.

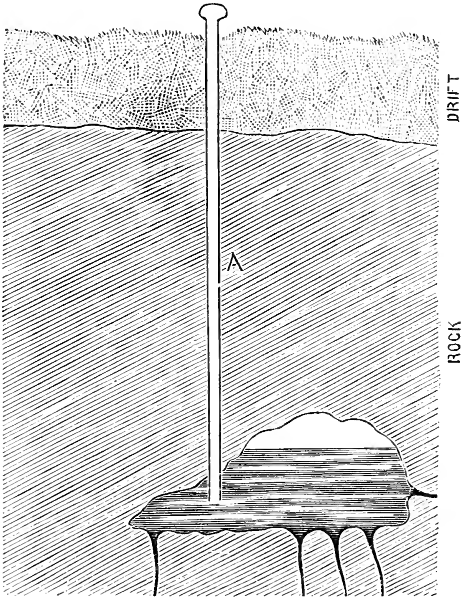
Fig. 2.



The second method (see Fig. 3) consists in drilling into the rock, in close proximity to the fault, until mineral water is obtained, the drill in the mean time being followed by an iron pipe, which effectually secures the flow, prevents the access of fresh water, and protects the rock through which the drill passes from the combined disintegrating action of both the water and carbonic-acid gas. Most of the springs secured in this manner are spouting in character; their flow is not, however, continuous, but spasmodic or intermittent. This peculiarity is undoubtedly due to a pocket or cavity in the rock, as represented in Fig. 3. A is the tube leading from the pocket to the surface. As the water flows into the pocket from the surrounding inlets, it gradually rises above the outlet, which results in the compression of

the gas between the roof of the cavity and the surface of the accumulating water; when the force of the compression reaches its maximum, it drives the water from the chamber up through the tube, from which it escapes in some instances to a distance of thirty feet in a ver-

Fig. 3.



tical direction. After the pent-up water and gas have escaped, the spouting ceases for a short time until the conditions are favorable for its repetition, when the process is continued. The springs secured by this method are the Vichy, Geyser, Champion, Kissingen, and the so-called magnetic. In depth they vary from fifty to three hundred feet. So far as the temperature of the springs is concerned they are practically isothermal, the maximum being 52° and the minimum 40° Fahr.; and in no instance are they affected by external causes, both their flow and temperature being uniform throughout the year. From the fact that the perpendicular iron tubes, through which the waters flow from certain wells, are capable of communicating magnetic properties to steel, the term magnetic springs has been applied to them in various sections of the country. Notwithstanding assertions to the contrary, the water from such springs has been pronounced totally devoid of any properties of a magnetic character by those who have investigated this phenomenon. All of the magnetic properties connected with such springs reside in the iron tubing, which becomes magnetic when placed in the ground in a vertical position in localities where the conditions are favorable; this result is said to be more likely to be attained if the tube is inclined a few degrees to the north.

CONSTITUENTS	High Rock. 1767. Professor Chandler.	Red. 1784. Professor Appleton.	Congress. 1792. Professor Chandler.	Columbian. 1805. Professor Emmons.	Hamilton. 1806. Dr. Steele.	Washington. 1806. Dr. Chilton.	Putnam. 1835. Dr. Chilton.	Star. 1835. Professor Chandler.	Pavilion. 1839. Professor Chandler.	United States. 1839. Professor Chandler.	Empire. 1846. Professor Chandler.
Acid boracic	......	......	......	......	......	......	......	......	......	......	......
Acid silicic	......	......	......	......	......	1·500	......	......	......	......	......
Alumina	1·223	......	trace.	......	......	trace.	0·560	trace.	0·329	0·094	0·418
Alumina and ferric oxide	......	2·100	......	......	......	......	......	......	......	......	......
Barium bicarbonate	trace.	......	0·928	......	......	......	......	0·996	0·875	0·909	0·070
Calcium bicarbonate	131·739	101·256	143·399	68·000	92·400	84·096	68·800	124·459	120·169	93·119	169·656
Calcium chloride	......	......	......	......	......	·203	......	......	......	......	......
Calcium fluoride	trace.	......	trace.	......	......	......	......	trace.	trace.	trace.	trace.
Calcium phosphate	trace.	......	......	......	......	......	·210	......	......	......	......
Calcium sulphate	......	......	......	......	......	......	......	......	......	......	......
Ferrous bicarbonate	1·478	......	0·340	5·580	5·390	3·800	7·000	1·213	2·570	0·714	0·793
Lithium bicarbonate	......	·942	4·761	......	......	......	......	1·586	9·486	4·847	2·080
Magnesium bicarbonate	54·924	42·413	121·757	46·710	35·200	65·973	51·600	61·912	76·267	72·883	42·953
Magnesium chloride	......	......	......	......	......	·680	......	......	......	......	......
Magnesium sulphate	......	......	......	......	......	·051	......	......	......	......	......
Phosphates	......	trace.	......	......	......	......	......	......	......	......	......
Potassium bromide	......	......	......	trace.	trace.	·474	......	......	......	......	......
Potassium chloride	8·497	6·857	8·049	......	......	......	......	9·695	7·660	8·624	4·292
Potassium silicate	......	......	......	......	......	......	......	......	......	......	......
Potassium sulphate	1·608	......	0·889	......	......	......	......	5·400	2·032	......	2·769
Silica	2·260	3·255	0·840	2·050	......	......	0·840	1·283	3·155	3·184	1·458
Strontium bicarbonate	trace.	trace.	trace.	......	......	......	......	trace.	trace.	0·018	trace.
Strontium sulphate	......	......	......	......	......	......	......	......	......	......	......
Sodium biborate	......	......	trace.	......	......	......	......	trace.	trace.	trace.	trace.
Sodium bicarbonate	34·888	15·327	10·775	15·400	27·036	8·474	14·320	12·662	3·764	4·666	9·022
Sodium bromide	0·731	......	8·559	......	......	......	......	0·571	0·987	0·844	0·266
Sodium chloride	390·127	83·530	400·444	267·000	297·300	182·733	214·000	398·361	459·903	141·872	506·630
Sodium iodide	0·086	......	0·138	2·560	3·000	2·243	2·000	0·126	0·071	0·047	0·006
Sodium phosphate	......	......	0·016	......	......	......	......	trace.	0·007	0·016	0·023
Sodium silicate	......	......	......	......	......	......	......	......	......	......	......
Sodium sulphate	......	......	......	......	......	......	1·680	......	......	......	......
Organic matter	trace.	......	......	......	......	......	......	trace.	trace.	trace.	trace.
Total United States gallon	628·039	254·719	700·895	407·300	460·326	350·227	361·010	617·367	687·275	331·887	680·436
Carbonic-acid gas	409·458	......	392·289	272·060	316·000	363·770	348·880	407·650	332·458	245·734	344·669
Density	......	......	......	......	......	......	......	1·0091	1·0075	1·0035	......
Temperature	52° F.	......	......	......	50° F.	45° F.	51° F.	50° F.	......	......	......

CONSTITUENTS.	Excelsior. 1859. Dr. Allen.	Saratoga A. 1865. Dr. Pohle.	Seltzer. 1865. Professor Chandler.	Union. 1868. Professor Chandler.	Hathorn. 1868. Professor Chandler.	Eureka. 1868. Dr. Allen.	Geyser. 1870. Professor Chandler.	Crystal. 1870. Professor Chandler.	Champion. 1871. Professor Chandler.	Vichy. 1872. Professor Chandler.	Kissingen. 1872. Professor Sharples.
Acid boracic	......	......	trace.	......	......	......	......	......	......	......	......
Acid silicic	......	1·460	......	......	......	......	......	......	......	......	......
Alumina	......	0·380	0·374	0·324	0·131	0·231	trace.	0·305	0·458	0·473	trace.
Alumina and ferric oxide	......	......	......	......	......	......	......	......	......	......	......
Barium bicarbonate	......	......	trace.	1·703	1·737	......	2·014	0·726	2·083	0·593	0·992
Calcium bicarbonate	77·030	56·852	89·869	96·703	170·646	41·321	168·392	101·881	227·070	95·522	140·260
Calcium chloride	......	trace.	......	......	......	......	......	......	......	......	......
Calcium fluoride	......	......	trace.	trace.	trace.	......	trace.	trace.	trace.	trace.	trace.
Calcium phosphate	......	......	trace.	......	......	......	......	......	......	......	......
Calcium sulphate	......	0·448	......	......	......	......	......	......	......	......	......
Ferrous bicarbonate	3·215	1·724	1·703	0·269	1·128	3·000	0·979	2·028	0·647	0·052	1·557
Lithium bicarbonate	......	1·724	0·899	2·605	11·447	......	9·004	4·326	6·247	1·760	5·129
Magnesium bicarbonate	32·333	20·480	40·839	109·685	176·463	29·340	149·343	75·161	193·912	41·503	70·470
Magnesium chloride	......	trace.	......	......	......	......	......	......	......	......	......
Magnesium sulphate	......	0·288	......	......	......	2·148	......	......	......	......	......
Phosphates	......	......	......	......	......	......	......	......	......	......	......
Potassium bromide	trace.	......	......	......	......	1·566	......	......	......	......	......
Potassium chloride	......	0·357	1·335	8·733	9·597	......	24·634	8·327	40·446	14·113	16·980
Potassium silicate	7·000	......	......	......	......	......	......	......	......	......	......
Potassium sulphate	......	0·370	0·557	1·818	......	......	0·318	2·158	0·252	trace.	trace.
Silica	......	......	2·561	2·653	1·260	0·532	0·665	3·213	0·699	0·758	1·280
Strontium bicarbonate	......	......	trace.	trace.	trace.	......	0·425	trace.	0·082	trace.	trace.
Strontium sulphate	trace.	......	......	......	......	......	......	......	......	......	......
Sodium biborate	......	......	trace.	trace.	trace	......	trace.	trace.	trace.	trace.	......
Sodium bicarbonate	15·000	6·752	29·428	17.010	4·288	8·750	71·232	10·064	17·624	82·873	67·617
Sodium bromide	......	......	0·630	1·307	1·534	......	2·212	0·414	3·579	0·990	1·800
Sodium chloride	370·642	565·300	134·291	453·299	509·968	166·811	562·080	328·468	702·239	128·689	338·500
Sodium iodide	4·2[illegible]5	......	0·031	0·039	0·198	4·666	0·248	0·066	0·234	trace.	0·042
Sodium phosphate	......	......	trace.	0·026	0·006	......	trace.	0·009	0·010	trace.	......
Sodium silicate	4·000	......	......	......	......	......	......	......	......	......	......
Sodium sulphate	1·321	2·590	......	......	......	......	......	......	......	......	......
Organic matter	......	trace.	trace.	trace.	trace.	......	trace.	trace.	trace.	trace.	......
Total United States gallon	514·746	656·911	302·017	701·174	888·408	258·365	991·546	537·155	1,195·582	315·176	644·627
Carbonic-acid gas	250·000	212·000	324·080	384·969	375·747	239·000	454·082	317·452	465·458	383·071	361·500
Density	......	......	1·0034	......	1·009	......	1·011	1·006	......	......	1·006
Temperature	......	......	50° F.	48° F.	47° F.	......	46° F.	50° F.	49° F.	50° F.	40° F.

With the exception of the High Rock, nothing of especial interest has attended the efforts to secure any of these waters. This spring takes its name from the pyramidal formation, which is composed of tufa, formed by the gradual deposition of the calcareous and other mineral matter that has been precipitated from the water as it flowed from its outlet. Up to 1865 there had never been any attempt made to secure the flow by artificial means, but in that year the proprietors conceived the idea of removing the tufaceous rock, and by excavating to a sufficient depth obtain water of better quality and in greater abundance. In accordance with this design, the rock, which measured four feet in height and about eight in diameter at the base, was carefully removed from its original position, and the work was commenced. After having penetrated the superficial deposits, a layer of seven feet of commingled muck and tufa, superimposed upon two feet of tufa, was encountered. Immediately below this the workmen found the trunk of a *Pinus alba*, which measured about a foot in diameter, and which was in a fair state of preservation. The next stratum was tufa, three feet in thickness, below which was two feet of drift. Lying immediately below this, a glacial clay bed, eighteen inches in thickness, was found, upon the surface of which an ancient hearth was discovered, composed of a semicircular row of stones, partially surrounding a quantity of charcoal, over which an incrustation of tufa was deposited. This circumstance was one of particular interest to students of archæology, as it involved the solution of a vexed question regarding the time at which the fire was kindled, as well as the character of the race, and the manners and customs of those by whom it was lighted. Inasmuch as the relic was discovered below the drift formation, its builders might have lived at a period anterior to that of the mound-builders of the Mississippi Valley. After having penetrated to the calciferous sand-rock, the tube was adjusted and the High Rock replaced, from the apex of which the water has continued to flow.

At the present time there are probably forty mineral springs within the limits of this town. Thirty of this number have received names, and twenty-two have been analyzed. The table appended * shows the proportions of the various constituents contained in a United States gallon of two hundred and thirty-one cubic inches.

To a certain extent the classification of mineral waters is an arbitrary one, different authorities following their own inclinations in their arrangement. By many they are divided into four classes, as follows:

1. Gaseous or acidulous: those in which carbonic-acid gas is a predominating constituent.

2. Saline, or those in which various salts are held in solution, in addition to the gas.

* At the top of each column the name of the spring, the year when discovered or tubed, and the name of the analyst, are given.

3. Chalybeate or ferruginous: those in which iron is a leading constituent; and—

4. Sulphurous: those that contain sulphureted hydrogen.

Of the latter class there are two instances.

Almost without exception the rest of the waters of this locality possess some of the properties of those belonging to the first three classes, being a combination of gaseous, saline, and ferruginous principles, their difference, as you will observe, being more one of quantity than of quality. As a matter of convenience they are designated as cathartic, alkaline, iron, and sulphur waters, according to the degree in which these characteristics present themselves.

Mineral waters were known at an early day, their use being held in high repute by the ancient Greeks and Romans, as well as by their less illustrious successors. Their physiological action and therapy are not, however, perfectly understood. With the exception of the chalybeate, the persistent use of the cathartic, alkaline, and sulphur waters favors retrograde metamorphic action, the ferruginous alone producing an opposite effect and increasing the number of the red blood-corpuscles.

From the diversified character of their constituents their application as therapeutic agents must necessarily have a wide range. Probably the best results from their use are obtained in those functional diseases that are connected with derangement of the portal circulation, and in certain rheumatic and arthritic affections. In some forms of indigestion their use is attended by very gratifying results, as well as in certain types of renal difficulties. In anæmia, uncomplicated with organic lesions, the iron waters are of decided benefit. That many persons injure themselves from the injudicious use of the waters is a matter of common observation. They are medicinal, and should be so regarded and used accordingly. The late Dr. Steele, in referring to this subject, remarked that "there are numerous persons who flock about the Springs during the drinking-season, without any knowledge of the composition of the waters, and little or none of their effects, who continue to dispose of their directions to the ignorant and unwary, with no other effect than to injure the reputation of the water and destroy the prospects of the diseased."

ACTION OF RADIANT HEAT ON GASEOUS MATTER.

By Professor JOHN TYNDALL, F. R. S.

THE Royal Society has already done me the honor of publishing a long series of memoirs on the interaction of radiant heat and gaseous matter. These memoirs did not escape criticism. Distinguished men, among whom the late Professor Magnus and the late Professor

Buff may be more specially mentioned, examined my experiments, and arrived at results different from mine. Living workers of merit have also taken up the question: the latest of whom,* while justly recognizing the extreme difficulty of the subject, and while verifying, so far as their experiments reach, what I had published regarding dry gases, find me to have fallen into what they consider grave errors in my treatment of vapors.

None of these investigators appear to me to have realized the true strength of my position in its relation to the objects I had in view. Occupied for the most part with details, they have failed to recognize the stringency of my work as a whole, and have not taken into account the independent support rendered by the various parts of the investigation to each other. They thus ignore verifications, both general and special, which are to me of conclusive force. Nevertheless, thinking it due to them and me to submit the questions at issue to a fresh examination, I resumed, some time ago, the threads of the inquiry. The results shall, in due time, be communicated to the Royal Society; but, meanwhile, I would ask permission to bring to the notice of the Fellows a novel mode of testing the relations of radiant heat to gaseous matter, whereby singularly instructive effects have been obtained.

After working for some time with the thermopile and galvanometer, it occurred to me several weeks ago that the results thus obtained might be checked by a more direct and simple form of experiment. Placing the gases and vapors in diathermanous bulbs, and exposing the bulbs to the action of radiant heat, the heat absorbed by different gases and vapors ought, I considered, to be rendered evident by ordinary expansion. I devised an apparatus with a view of testing this idea. But, at this point, and before my proposed gas-thermometer was constructed, I became acquainted with the ingenious and original experiments of Mr. Graham Bell, wherein musical sounds are obtained through the action of an intermittent beam of light upon solid bodies.

From the first, I entertained the opinion that these singular sounds were caused by rapid changes of temperature, producing corresponding changes of shape and volume in the bodies impinged upon by the beam. But if this be the case, and if gases and vapors really absorb radiant heat, they ought to produce sounds more intense than those obtainable from solids. I pictured every stroke of the beam responded to by a sudden expansion of the absorbent gas, and concluded that, when the pulses thus excited followed each other with sufficient rapidity, a musical note must be the result. It seemed plain, moreover, that by this new method many of my previous results might be brought to an independent test. Highly diathermanous bodies, I

* MM. Lecher and Pernter, "Philosophical Magazine," January, 1881; "Sitzb. der k. Akad. der Wissench. in Wien," July, 1880.

reasoned, would produce faint sounds, while highly athermanous bodies would produce loud sounds; the strength of the sound being, in a sense, a measure of the absorption. The first experiment made, with a view of testing this idea, was executed in the presence of Mr. Graham Bell; * and the result was in exact accordance with what I had foreseen.

The inquiry has been recently extended so as to embrace most of the gases and vapors employed in my former researches. My first source of rays was a Siemens lamp connected with a dynamo-machine, worked by a gas-engine. A glass lens was used to concentrate the rays, and afterward two lenses. By the first the rays were rendered parallel, while the second caused them to converge to a point about seven inches distant from the lens. A circle of sheet-zinc provided first with radial slits and afterward with teeth and interspaces, cut through it, was mounted vertically on a whirling table, and caused to rotate rapidly across the beam near the focus. The passage of the slits produced the desired intermittence, † while a flask containing the gas or vapor to be examined received the shocks of the beam immediately behind the rotating disk. From the flask a tube of India-rubber, ending in a tapering one of ivory or boxwood, led to the ear, which was thus rendered keenly sensitive to any sound generated within the flask. Compared with the beautiful apparatus of Mr. Graham Bell, the arrangement here described is rude; it is, however, very effective.

With this arrangement the number of sounding gases and vapors was rapidly increased. But I was soon made aware that the glass lenses withdrew from the beam its most effectual rays. The silvered mirrors employed in my previous researches were therefore invoked; and with them, acting sometimes singly and sometimes as conjugate mirrors, the curious and striking results which I have now the honor to submit to the Society were obtained.

Sulphuric ether, formic ether, and acetic ether, being placed in bulbous flasks,‡ their vapors were soon diffused in the air above the liquid. On placing these flasks, whose bottoms only were covered by the liquid, behind the rotating disk, so that the intermittent beam

* On the 29th November: see "Journal of the Society of Telegraph Engineers," December 8, 1880.

† When the disk rotates, the individual slits disappear, forming a hazy zone through which objects are visible. Throwing by the clean hand, or better still by white paper, the beam back upon the disk, it appears to stand still, the slits forming so many dark rectangles. The reason is obvious, but the experiment is a very beautiful one.

I may add that when I stand with open eyes in the flashing beam, at a definite velocity of recurrence, subjective colors of extraordinary gorgeousness are produced. With slower or quicker rates of rotation the colors disappear. The flashes also produce a giddiness sometimes intense enough to cause me to grasp the table to keep myself erect.

‡ I have employed flasks measuring from eight inches to three-fourths of an inch in diameter. The smallest flask, which had a stem with a bore of about one eighth of an inch in diameter, yielded better effects than the largest. Flasks from two to three inches in diameter yield good results. Ordinary test-tubes also answer well.

passed through the vapor, loud musical tones were in each case obtained. These are known to be the most highly absorbent vapors which my experiments revealed. Chloroform and bisulphide of carbon, on the other hand, are known to be the least absorbent, the latter standing near the head of diathermanous vapors. The sounds extracted from these two substances were usually weak and sometimes barely audible, being more feeble with the bisulphide than with the chloroform. With regard to the vapors of amylene, iodide of ethyl, iodide of methyl and benzol, other things being equal, their power to produce musical tones appeared to be accurately expressed by their ability to absorb radiant heat.

It is the vapor, and not the liquid, that is effective in producing the sounds. Taking, for example, the bottles in which my volatile substances are habitually kept, I permitted the intermittent beam to impinge upon the liquid in each of them. No sound was in any case produced, while, the moment the vapor-laden space above an active liquid was traversed by the beam, musical tones made themselves audible.

A rock-salt cell filled entirely with a volatile liquid, and subjected to the intermittent beam, produced no sound. This cell was circular and closed at the top. Once, while operating with a highly athermanous substance, a distinct musical note was heard. On examining the cell, however, a small bubble was found at its top. The bubble was less than a quarter of an inch in diameter, but still sufficient to produce audible sounds. When the cell was completely filled, the sounds disappeared.

It is hardly necessary to state that the pitch of the note obtained in each case is determined by the velocity of rotation. It is the same as that produced by blowing against the rotating disk and allowing its slits to act like the perforations of a siren.

Thus, as regards vapors, prevision has been justified by experiment. I now turn to gases. A small flask, after having been heated in the spirit-lamp so as to detach all moisture from its sides, was carefully filled with dried air. Placed in the intermittent beam it yielded a musical note, but so feeble as to be heard only with attention. Dry oxygen and hydrogen behaved like dry air. This agrees with my former experiments, which assigned a hardly sensible absorption to these gases. When the dry air was displaced by carbonic acid, the sound was far louder than that obtained from any of the elementary gases. When the carbonic acid was displaced by nitrous oxide, the sound was much more forcible still, and, when the nitrous oxide was displaced by olefiant gas, it gave birth to a musical note which, when the beam was in good condition and the bulb well chosen, seemed as loud as that of an ordinary organ-pipe.* We have here the exact order

* With conjugate mirrors, the sounds with olefiant gas are readily obtained at a distance of twenty yards from the lamp. I hope to be able to make a candle-flame effective in these experiments.

in which my former experiments proved these gases to stand as absorbers of radiant heat. The amount of the absorption and the intensity of the sound go hand in hand.

A soap-bubble blown with nitrous oxide, or olefiant gas, and exposed to the intermittent beam, produced no sound, no matter how its size might be varied. The pulses obviously expended themselves upon the flexible envelope, which transferred them to the air outside.

But a film thus impressionable to impulses on its interior surface must prove at least equally sensible to sonorous waves impinging on it from without. Hence, I inferred, the eminent suitability of soap-bubbles for sound-lenses. Placing a "sensitive flame" some feet distant from a small sounding reed, the pressure was so arranged that the flame burned tranquilly. A bubble of nitrous oxide (specific gravity 1·527) was then blown, and placed in front of the reed. The flame immediately fell and roared, and continued agitated as long as the lens remained in position. A pendulous motion could be imparted to the bubble, so as to cause it to pass to and fro in front of the reed. The flame responded, by alternately roaring and becoming tranquil, to every swing of the bubble. Nitrous oxide is far better for this experiment than carbonic acid, which speedily ruins its envelope.

The pressure was altered so as to throw the flame, when the reed sounded, into violent agitation. A bubble blown with hydrogen (specific gravity 0·069) being placed in front of the reed, the flame was immediately stilled. The ear answers instead of the flame.

In 1859 I proved gaseous ammonia to be extremely impervious to radiant heat. My interest in its deportment when subjected to this novel test was therefore great. Placing a small quantity of liquid ammonia in one of the flasks, and warming the liquid slightly, the intermittent beam was sent through the space above the liquid. A loud musical note was immediately produced. By the proper application of heat to a liquid the sounds may be always intensified. The ordinary temperature, however, suffices in all the cases thus far referred to. In this relation the vapor of water was that which interested me most, and, as I could not hope that at ordinary temperatures it existed in sufficient amount to produce audible tones, I heated a small quantity of water in a flask almost up to its boiling-point. Placed in the intermittent beam, I heard—I avow with delight—a powerful musical sound produced by the aqueous vapor.

Small wreaths of haze, produced by the partial condensation of the vapor in the upper and cooler air of the flask, were, however, visible in this experiment; and it was necessary to prove that this haze was not the cause of the sound. The flask was, therefore, heated by a spirit-flame beyond the temperature of boiling water. The closest scrutiny by a condensed beam of light then revealed no trace of cloudiness above the liquid. From the perfectly invisible vapor, however, the musical sound issued, if anything, more forcible than before. I

placed the flask in cold water until its temperature was reduced from about 90° to 10° C., fully expecting that the sound would vanish at this temperature; but, notwithstanding the tenuity of the vapor, the sound extracted from it was not only distinct but loud.

Three empty flasks, filled with ordinary air, were placed in a freezing mixture for a quarter of an hour. On being rapidly transferred to the intermittent beam, sounds much louder than those obtainable from dry air were produced. Warming these flasks in the flame of a spirit-lamp until all visible humidity had been removed, and afterward urging dried air through them, on being placed in the intermittent beam the sound in each case was found to have fallen almost to silence. Sending, by means of a glass tube, a puff of breath from the lungs into a dried flask, the power of emitting sound was immediately restored. When, instead of breathing into a dry flask, the common air of the laboratory was urged through it, the sounds became immediately intensified. I was by no means prepared for the extraordinary delicacy of this new method of testing the athermancy and diathermancy of gases and vapors, and it can not be otherwise than satisfactory to me to find that particular vapor, whose alleged deportment toward radiant heat has been so strenuously denied, affirming thus audibly its true character.

After what has been stated regarding aqueous vapor, we are prepared for the fact that an exceedingly small percentage of any highly athermanous gas diffused in air suffices to exalt the sounds. An accidental observation will illustrate this point. A flask was filled with coal-gas, and held bottom upward in the intermittent beam. The sounds produced were of a force corresponding to the known absorptive energy of coal-gas. The flask was then placed upright, with its mouth open upon a table, and permitted to remain there for nearly an hour. On being restored to the beam, the sounds produced were far louder than those which could be obtained from common air.*

Transferring a small flask or a test-tube from a cold place to the intermittent beam, it is sometimes found to be practically silent for a moment, after which the sounds become distinctly audible. This I take to be due to the vaporization by the calorific beam of the thin film of moisture adherent to the glass.

My previous experiments having satisfied me of the generality of the rule that volatile liquids and their vapors absorb the same rays, I thought it probable that the introduction of a thin layer of its liquid, even in the case of a most energetic vapor, would detach the effective rays, and thus quench the sounds. The experiment was made, and the conclusion verified. A layer of water, formic ether, sulphuric ether, or acetic ether, one eighth of an inch in thickness, rendered the transmitted beam powerless to produce any musical sound. These

* The method here described is, I doubt not, applicable to the detection of extremely small quantities of fire-damp in mines.

liquids being transparent to light, the efficient rays which they intercepted must have been those of obscure heat.

A layer of bisulphide of carbon, about ten times the thickness of the transparent layers just referred to, and rendered opaque to light by dissolved iodine, was interposed in the path of the intermittent beam. It produced hardly any diminution of the sounds of the more active vapors—a further proof that it is the invisible heat-rays, to which the solution of iodine is so eminently transparent, that are here effectual.

Converting one of the small flasks used in the foregoing experiments into a thermometer-bulb, and filling it with various gases in succession, it was found that with those gases which yielded a feeble sound the displacement of a thermometric column associated with the bulb was slow and feeble, while with those gases which yielded loud sounds the displacement was prompt and forcible.

Since the handing in of the foregoing note, on the 3d of January, the experiments have been pushed forward, augmented acquaintance with the subject serving only to confirm my estimate of its interest and importance. All the results described in my first note have been obtained in a very energetic form with a battery of sixty Grove's cells.

On the 4th of January I chose for my source of rays a powerful lime-light, which, when sufficient care is taken to prevent the pitting of the cylinder, works with admirable steadiness and without any noise. I also changed my mirror for one of shorter focus, which permitted a nearer approach to the source of rays. Tested with this new reflector the stronger vapors rose remarkably in sounding power.

Improved manipulation was, I considered, sure to extract sounds from rays of much more moderate intensity than those of the lime-light. For this light, therefore, a common candle flame was substituted. Received and thrown back by the mirror, the radiant heat of the candle produced audible tones in all the stronger vapors. Abandoning the mirror and bringing the candle close to the rotating disk, its direct rays produced audible sounds. A red-hot coal, taken from the fire and held close to the rotating disk, produced forcible sounds in a flask at the other side. A red-hot poker, placed in the position previously occupied by the coal, produced strong sounds. Maintaining the flask in position behind the rotating disk, amusing alternations of sound and silence accompanied the alternate introduction and removal of the poker. The temperature of the iron was then lowered till its heat just ceased to be visible. The intermittent invisible rays produced audible sounds. The temperature was gradually lowered, being accompanied by a gradual and continuous diminution of the sound. When it ceased to be audible the temperature of the poker was found to be below that of boiling water.

As might be expected from the foregoing experiments, an incandes-

cent platinum spiral, with or without the mirror, produced musical sounds. When the battery power was reduced from ten cells to three, the sounds, though enfeebled, were still distinct.

My neglect of aqueous vapor had led me for a time astray in 1859, but before publishing my results I had discovered my error. On the present occasion this omnipresent substance had also to be reckoned with. Fourteen flasks of various sizes, with their bottoms covered with a little sulphuric acid, were closed with ordinary corks and permitted to remain in the laboratory from the 23d of December to the 4th of January. Tested on the latter day with the intermittent beam, half of them emitted feeble sounds, but half were silent. The sounds were undoubtedly due, not to dry air, but to traces of aqueous vapor.

An ordinary bottle, containing sulphuric acid for laboratory purposes, being connected with the ear and placed in the intermittent beam, emitted a faint but distinct musical sound. This bottle had been opened two or three times during the day, its dryness being thus vitiated by the mixture of a small quantity of common air. A second similar bottle, in which sulphuric acid had stood undisturbed for some days, was placed in the beam: the dry air above the liquid proved absolutely silent.

On the evening of January 7th Professor Dewar handed me four flasks treated in the following manner: Into one was poured a small quantity of strong sulphuric acid; into another a small quantity of Nordhausen sulphuric acid; in a third were placed some fragments of fused chloride of calcium; while the fourth contained a small quantity of phosphoric anhydride. They were closed with well-fitting India-rubber stoppers, and permitted to remain undisturbed throughout the night. Tested after twelve hours, each of them emitted a feeble sound, the flask last mentioned being the strongest. Tested again six hours later, the sound had disappeared from three of the flasks, that containing the phosphoric anhydride alone remaining musical.

Breathing into a flask partially filled with sulphuric acid instantly restores the sounding power, which continues for a considerable time. The wetting of the interior surface of the flask with the sulphuric acid always enfeebles and sometimes destroys the sound.

A bulb, less than a cubic inch in volume, and containing a little water, lowered to the temperature of melting ice, produces very distinct sounds. Warming the water in the flame of a spirit-lamp, the sound becomes greatly augmented in strength. At the boiling temperature the sound emitted by this small bulb * is of extraordinary intensity.

These results are in accord with those obtained by me nearly nineteen years ago, both in reference to air and to aqueous vapor. They

* In such bulbs even bisulphide-of-carbon vapor may be so nursed as to produce sounds of considerable strength.

are in utter disaccord with those obtained by other experimenters, who have ascribed a high absorption to air and none to aqueous vapor.

The action of aqueous vapor being thus revealed, the necessity of thoroughly drying the flasks, when testing other substances, becomes obvious. The following plan has been found effective : Each flask is first heated in the flame of a spirit-lamp until every visible trace of internal moisture has disappeared, and it is afterward raised to a temperature of about 400° C. While the flask is still hot, a glass tube is introduced into it, and air, freed from carbonic acid by caustic potash and from aqueous vapor by sulphuric acid, is urged through the flask until it is cool. Connected with the ear-tube, and exposed immediately to the intermittent beam, the attention of the ear, if I may use the term, is converged upon the flask. When the experiment is carefully made, dry air proves as incompetent to produce sound as to absorb radiant heat.

In 1868 I determined the absorptions of a great number of liquids whose vapors I did not examine. My experiments having amply proved the parallelism of liquid and vaporous absorption, I held undoubtingly twelve years ago that the vapor of cyanide of ethyl and of acetic acid would prove powerfully absorbent. This conclusion is now easily tested. A small quantity of either of these substances, placed in a bulb a cubic inch in volume, warmed and exposed to the intermittent beam, emits a sound of extraordinary power.

I also tried to extract sounds from perfumes, which I had proved in 1861 to be absorbers of radiant heat. I limit myself here to the vapors of patchouly and cassia, the former exercising a measured absorption of 30, and the latter an absorption of 109. Placed in dried flasks, and slightly warmed, sounds were obtained from both these substances, but the sound of cassia was much louder than that of patchouly.

Many years ago I had proved tetrachloride of carbon to be highly diathermanous. Its sounding power is as feeble as its absorbent power.

In relation to colliery explosions, the deportment of marsh-gas was of special interest. Professor Dewar was good enough to furnish me with a pure sample of this gas. The sounds produced by it, when exposed to the intermittent beam, were very powerful. Chloride of methyl, a liquid which boils at the ordinary temperature of the air, was poured into a small flask, and permitted to displace the air within it. Exposed to the intermittent beam, its sound was similar in power to that of marsh-gas. The specific gravity of marsh-gas being about half that of air, it might be expected that the flask containing it, when left open and erect, would soon get rid of its contents. This, however, is not the case. After a considerable interval, the film of this gas clinging to the interior surface of the flask was able to produce sounds of great power.

A small quantity of liquid bromine being poured into a well-dried flask, the brown vapor rapidly difused itself in the air above the liquid. Placed in the intermittent beam, a somewhat forcible sound was produced. This might seem to militate against my former experiments, which assigned a very low absorptive power to bromine vapor. But my former experiments on this vapor were conducted with obscure heat; whereas, in the present instance, I had to deal with the radiation from incandescent lime, whose heat is, in part, luminous. Now, the color of the bromine vapor proves it to be an energetic absorber of the luminous rays; and to them, when suddenly converted into thermometric heat in the body of the vapor, I thought the sounds might be due.

Between the flasks containing the bromine and the rotating disk, I therefore placed an empty glass cell: the sounds continued. I then filled the cell with transparant bisulphide of carbon: the sounds still continued. For the transparent bisulphide I then substituted the same liquid saturated with dissolved iodine. This solution cut off the light while allowing the rays of heat free transmission: the sounds were immediately stilled.

Iodine, vaporized by heat in a small flask, yielded a forcible sound, which was not sensibly affected by the interposition of transparant bisulphide of carbon, but which was completely quelled by the iodine solution. It might indeed have been foreseen that the rays transmitted by the iodine as a liquid would also be transmitted by its vapor, and thus fail to be converted into sound.*

To complete the argument: While the flask containing the bromine vapor was sounding in the intermittent beam, a strong solution of alum was interposed between it and the rotating disk. There was no sensible abatement of the sounds with either bromine or iodine vapor.

In these experiments the rays from the lime-light were converged to a point a little beyond the rotating disk. In the next experiment they were rendered parallel by the mirror, and afterward rendered convergent by a lens of ice. At the focus of the ice-lens the sounds were extracted from both bromine and iodine vapor. Sounds were also produced after the beam had been sent through the alum solution and the ice-lens conjointly.

With a very rude arrangement I have been able to hear the sounds of the more active vapors at a distance of one hundred feet from the source of rays.

Several vapors other than those mentioned in this abstract have been examined, and sounds obtained from all of them. The vapors of all compound liquors will, I doubt not, be found sonorous in the intermittent beam. And, as I question whether there is an absolutely

* I intentionally use this phraseology.

diathermanous substance in nature, I think it probable that even the vapors of elementary bodies, including the elementary gases, when more strictly examined, will be found capable of producing sounds.

ANOTHER WORLD DOWN HERE.

By W. MATTIEU WILLIAMS.

WHAT a horrible place must this world appear when regarded according to our ideas from an insect's point of view! The air infested with huge flying hungry dragons, whose gaping and snapping mouths are ever intent upon swallowing the innocent creatures for whom, according to the insect, if he were like us, a properly constructed world ought to be exclusively adapted. The solid earth continually shaken by the approaching tread of hideous giants—moving mountains—that crush out precious lives at every footstep, an occasional draught of the blood of these monsters, stolen at life-risk, affording but poor compensation for such fatal persecution.

Let us hope that the little victims are less like ourselves than the doings of ants and bees might lead us to suppose; that their mental anxieties are not proportionate to the optical vigilance indicated by the four thousand eye-lenses of the common house-fly, the seventeen thousand of the cabbage-butterfly and the wide-awake dragon-fly, or the twenty-five thousand possessed by certain species of still more vigilant beetles.

Each of these little eyes has its own cornea, its lens, and a curious six-sided, transparent prism, at the back of which is a special retina spreading out from a branch of the main optic nerve, which, in the cockchafer and some other creatures, is half as large as the brain. If each of these lenses forms a separate picture of each object rather than a single mosaic picture, as some anatomists suppose, what an awful army of cruel giants must the cockchafer behold when he is captured by a schoolboy!

The insect must see a whole world of wonders of which we know little or nothing. True, we have microscopes, with which we can see one thing at a time if carefully laid upon the stage; but what is the finest instrument that Ross can produce compared to that with twenty-five thousand object-glasses, all of them probably achromatic, and each one a living instrument with its own nerve-branch supplying a separate sensation? To creatures thus endowed with microscopic vision, a cloud of sandy dust must appear like an avalanche of massive rock-fragments, and everything else proportionally monstrous.

One of the many delusions engendered by our human self-conceit and habit of considering the world as only such as we know it from

our human point of view is that of supposing human intelligence to be the only kind of intelligence in existence. The fact is, that what we call the lower animals have special intelligence of their own as far transcending our intelligence as our peculiar reasoning intelligence exceeds theirs. We are as incapable of following the track of a friend by the smell of his footsteps as a dog is of writing a metaphysical treatise.

So with insects. They are probably acquainted with a whole world of physical facts of which we are utterly ignorant. Our auditory apparatus supplies us with a knowledge of sounds. What are these sounds? They are vibrations of matter which are capable of producing corresponding or sympathetic vibrations of the drums of our ears or the bones of our skull. When we carefully examine the subject, and count the number of vibrations that produce our world of sounds of varying pitch, we find that the human ear can only respond to a limited range of such vibrations. If they exceed three thousand per second, the sound becomes too shrill for average people to hear it, though some exceptional ears can take up pulsations, or waves, that succeed each other more rapidly than this.

Reasoning from the analogy of stretched strings and membranes, and of air vibrating in tubes, etc., we are justified in concluding that the smaller the drum or tube the higher will be the note it produces when agitated, and the smaller and the more rapid the aërial wave to which it will respond. The drums of insect-ears, and the tubes, etc., connected with them, are so minute that their world of sounds probably begins where ours ceases; that what appears to us as a continuous sound is to them a series of separated blows, just as vibrations of ten or twelve per second appear separated to us. We begin to hear such vibrations as continuous sounds when they amount to about thirty per second. The insect's continuous sound probably begins beyond three thousand. The blue-bottle may thus enjoy a whole world of exquisite music of which we know nothing.

There is another very suggestive peculiarity in the auditory apparatus of insects. Its structure and position are something between those of an ear and of an eye. Careful examination of the head of one of our domestic companions—the common cockroach or black-beetle—will reveal two round white points, somewhat higher than the base of the long outer antennæ, and a little nearer to the middle line of the head. These white projecting spots are formed by the outer transparent membrane of a bag or ball filled with fluid, which ball or bag rests inside another cavity in the head. It resembles our own eye in having this external transparent tough membrane which corresponds to the cornea; which, like the cornea, is backed by the fluid in the ear-ball corresponding to our eyeball, and the back of this ear-ball appears to receive the outspreadings of a nerve, just as the back of our eye is lined with the outspread of the optic nerve forming the

retina. There does not appear to be in this or other insects a tightly stretched membrane which, like the membrane of our ear-drum, is fitted to take up bodily air-waves and vibrate responsively to them. But it is evidently adapted to receive and concentrate some kind of vibration or motion or tremor.

What kind of motion can this be? What kind of perception does this curious organ supply? To answer these questions we must travel beyond the strict limits of scientific induction and enter the fairy-land of scientific imagination. We may wander here in safety, provided we always remember where we are, and keep a true course guided by the compass-needle of demonstrable facts.

I have said that the cornea-like membrane of the insect's ear-bag does not appear capable of responding to *bodily* air-waves. This adjective is important, because there are vibratory movements of matter that are not bodily but molecular. An analogy may help to render this distinction intelligible. I may take a long string of beads and shake it into wave-like movements, the waves being formed by the movements of the whole string. We may now conceive another kind of movement or vibration by supposing one bead to receive a blow pushing it forward, this push to be communicated to the next, then to the third, and so on, producing a minute running tremor passing from end to end. This kind of action may be rendered visible by laying a number of billiard-balls or marbles in line and bowling an outside ball against the end one of the row. The impulse will be rapidly and invisibly transmitted all along the line, and the outer ball will respond by starting forward.

Heat, light, and electricity, are mysterious internal movements of what we call matter (some say "ether," which is but a name for imaginary matter). These internal movements are as invisible as those of the intermediate billiard-balls; but if there be a line of molecules acting thus, and the terminal one strikes an organ of sense fitted to receive its motion, some sort of perception may follow. When such movements of certain frequency and amplitude strike our organs of vision, the sensation of light is produced. When others of greater amplitude and smaller frequency strike the terminal outspread of our common sensory nerves, the sensation of heat results. The difference between the frequency and amplitude of the heat-waves and the light-waves is but small, or, strictly speaking, there is no actual line of separation lying between them; they run directly into each other. When a piece of metal is gradually heated, it is first "black-hot"; this is while the waves or molecular tremblings are of a certain amplitude and frequency; as the frequency increases, and amplitude diminishes (or, to borrow from musical terms, as the pitch rises), the metal becomes dull red-hot; greater rapidity, cherry-red; greater still, bright-red; then yellow-hot and white-hot: the luminosity growing as the rapidity of molecular vibration increases.

There is no such gradation between the most rapid undulations or tremblings that produce our sensation of sound and the slowest of those which give rise to our sensations of gentlest warmth. There is a huge gap between them, wide enough to include another world or several other worlds of motion, all lying between our world of sounds and our world of heat and light, and there is no good reason whatever for supposing that matter is incapable of such intermediate activity, or that such activity may not give rise to intermediate sensations, provided there are organs for taking up and sensifying (if I may coin a desirable word) these movements.

As already stated, the limit of audible tremors is three to four thousand per second, but the smallest number of tremors that we can perceive as heat is between three and four millions of millions per second. The number of waves producing red light is estimated at four hundred and seventy-four millions of millions per second; and for the production of violet light, six hundred and ninety-nine millions of millions. These are the received conclusions of our best mathematicians, which I repeat on their authority. Allowing, however, a very large margin of possible error, the world of possible sensations lying between those produced by a few thousands of waves and any number of millions is of enormous width.

In such a world of intermediate activities the insect probably lives, with a sense of vision revealing to him more than our microscopes show to us, and with his minute eye-like ear-bag sensifying material movements that lie between our world of sounds and our other far-distant worlds of heat and light.

There is yet another indication of some sort of intermediate sensation possessed by insects. Many of them are not only endowed with the thousands of lenses of their compound eyes, but have in addition several curious organs that have been designated "ocelli" and "stemmata." These are generally placed at the top of the head, the thousand-fold eyes being at the sides. They are very much like the auditory organs above described—so much so, that in consulting different authorities for special information on the subject I have fallen into some confusion, from which I can only escape by supposing that the organ which one anatomist describes as the ocelli of certain insects is regarded as the auditory apparatus when examined in another insect by another anatomist. All this indicates a sort of continuity of sensation connecting the sounds of the insect world with the objects of their vision.

But these ocular ears or auditory eyes of the insect are not his only advantages over us. He has another sensory organ to which, with all our boasted intellect, we can claim nothing that is comparable, unless it be our olfactory nerve. The possibility of this I will presently discuss.

I refer to the *antennæ*, which are the most characteristic of insect

organs, and wonderfully developed in some, as may be seen by examining the plumes of the crested gnat. Everybody who has carefully watched the doings of insects must have observed the curiously investigative movements of the antennæ, which are ever on the alert peering and prying to right and left and upward and downward. Huber, who devoted his life to the study of bees and ants, concluded that these insects converse with each other by movements of the antennæ, and he has given to the signs thus produced the name of "antennal language." They certainly do communicate information or give orders by some means; and, when they stop for that purpose, they face each other and execute peculiar wavings of these organs that are highly sugestive of the movements of the old semaphore-telegraph arms.

The most generally received opinion is, that these antennæ are very delicate organs of touch, but some recent experiments made by Gustav Hausen indicate that they are organs of smelling or of some similar power of distinguishing objects at a distance. Flies deprived of their antennæ ceased to display any interest in tainted meat that had previously proved very attractive. Other insects similarly treated appear to become indifferent to odors generally. He shows that the development of the antennæ in different species corresponds to the power of smelling which they seem to possess.

I am sorely tempted to add another argument to those brought forward by Hausen, viz., that our own olfactory nerves, and those of all our near mammalian relations, are curiously like a pair of antennæ.

There are two elements in a nervous structure—the gray and the white; the gray or ganglionic portion is supposed to be the center or seat of nervous power, and the white medullary or fibrous portion merely the conductor of nervous energy.

The nerves of the other senses have their ganglia seated internally, and the bundles of tubular white threads spread outward therefrom, but not so with the olfactory nervous apparatus. There are two horn-like projections thrust forward from the base of the brain, with white or medullary stems that terminate outwardly or anteriorly in ganglionic bulbs resting upon what I may call the roof of the nose, and throwing out fibers that are composed, rather paradoxically, of more gray matter than white. In some quadrupeds with great power of smell, these two nerves extend so far forward as to protrude beyond the front of the hemispheres of the brain, with bulbous terminations relatively very much larger than those of man.

They thus appear like veritable antennæ. In some of our best works on anatomy of the brain (Solly, for example) a series of comparative pictures of the brains of different animals is shown, extending from man to the codfish. As we proceed downward, the horn-like projection of the olfactory nerves beyond the central hemispheres goes on extending more and more, and the relative magnitude of the terminal ganglia or olfactory lobes increases in similar order.

We have only to omit the nasal bones and nostrils, to continue this forward extrusion of the olfactory nerves and their bulbs and branches, to coat them with suitable sheaths provided with muscles for mobility, and we have the antennæ of insects. I submit this view of the comparative anatomy of these organs as my own speculation, to be taken for what it is worth.

There is no doubt that the antennæ of these creatures are connected by nerve-stalks with the anterior part of their supra-œsophageal ganglia—i. e., the nervous centers corresponding to our brain.

But what kind and degree of power must such olfactory organs possess? The dog has, relatively to the rest of his brain, a much greater development of the olfactory nerves and ganglia than man has. His powers of smell are so much greater than ours that we find it difficult to conceive the possibility of what we actually see him do. As an example, I may describe an experiment I made upon a blood-hound of the famous Cuban breed. He belonged to a friend whose house is situated on an eminence commanding an extensive view. I started from the garden and wandered about a mile away, crossed several fields by sinuous courses, climbing over stiles and jumping ditches, always keeping the house in view; I then returned by quite a different track. The blood-hound was set upon the beginning of my track. I watched him from a window galloping rapidly, and following all its windings without the least halting or hesitation. It was as clear to his nose as a graveled path or a luminous streak would be to our eyes. On his return I went down to him, and without approaching nearer than five or six yards he recognized me as the object of his search, proving this by circling round me, baying deeply and savagely though harmlessly, as he always kept at about the same distance.

If the difference of development between the human and canine internal antennæ produces all this difference of function, what a gulf may there be between our powers of perceiving material emanations and those possessed by insects! If my anatomical hypothesis is correct, some insects have protruding nasal organs or out-thrust olfactory nerves as long as all the rest of their bodies. The power of movement of these in all directions affords the means of sensory communication over a corresponding range, instead of being limited merely to the direction of the nostril-openings. In some insects, such as the plumed gnat, the antennæ do not appear to be thus movable, but this want of mobility is more than compensated by the multitude of branchings of these wonderful organs whereby they are simultaneously exposed in every direction. This structure is analogous to the fixed but multiplied eyes of insects, which, by seeing all round at once, compensate for the want of that mobility possessed by others that have but a single eyeball mounted on a flexible and mobile stalk; that of the spider, for example.

Such an extension of such a sensory function is equivalent to liv-

ing in another world of which we have no knowledge and can form no definite conception. We, by our senses of touch and vision, know the shapes and colors of objects, and by our very rudimentary olfactory organs form crude ideas of their chemistry or composition, through the medium of their material emanations; but the huge exaggeration of this power in the insect should supply him with instinctive perceptive powers of chemical analysis, a direct acquaintance with the inner molecular constitution of matter far clearer and deeper than we are able to obtain by all the refinements of laboratory analyses or the hypothetical formulating of molecular mathematicians. Add this to the other world of sensations producible by the vibratory movements of matter lying between those perceptible by our organs of hearing and vision, then strain your imagination to its cracking-point, and you will still fail to picture the wonder-land in which the smallest of our fellow-creatures may be living, moving, and having their being.—*Belgravia.*

THE ORIGIN AND STRUCTURE OF VOLCANIC CONES.

BY H. J. JOHNSTON-LAVIS, F. G. S.

II.

IT is observable in certain volcanoes that the lava frequently strewed around after an eruption contains more or less perfect spheres, consisting of a hard external coat and more scoriaceous contents, and these from their resemblance are known as volcanic bombs. Their contents may be divided into two classes:

1. Scoriaceous vesicular lava, identical in composition with the external shell.

2. Miscellaneous, such as altered masses of lapilli, loose blocks of foreign materials caught up in the current of lava. These balls are generally considered to be formed by the masses being ejected to great heights, and cooling as they whirl through the atmosphere.

This seems improbable, as on falling they would inevitably smash into a thousand fragments. It would appear more likely that they are simply concretionary in structure around a nucleus of low temperature, solidifying on the surface a layer forming a crust of lava. Let us now direct our attention to the minor particulars, such as the changes of the crater, and metamorphism, or alteration of the already ejected materials. If the volcano has already reached some considerable dimensions, effected by one or many eruptions, we shall find that certain definite changes have taken place in the chimney. The eruption is reduced in force, there are spasmodic puff-like ejections of la-

pilli, and occasionally small streams of lava emitted. Before entering further into our subject, we must return a step or two. It has been mentioned that the inclination of the outer slope of the cone is that of the "angle of repose" of the rock-fragments. We should, therefore,

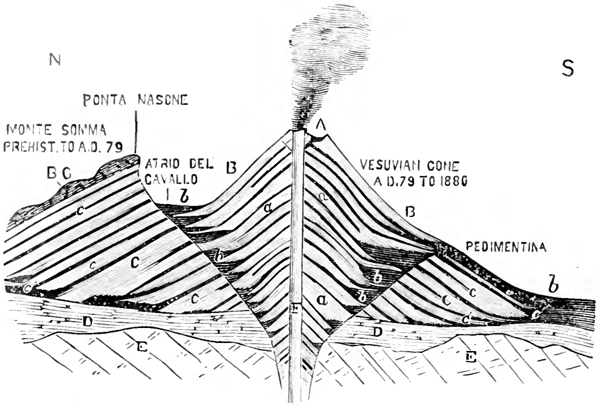


Fig. 1.—A. Cone of Eruption built up in the Crater of 1878: B. Vesuvius proper, this cone composed of alternate lava-streams *b*, and lapilli *a*, built up since A. D. 79. It occupies the crater of Somma; C. This is composed like the latter, of alternate beds of lava *c'* and lapilli *c*; B. C. Deposits of pumice and trachytic fragments, etc., capping all exposed parts of Somma derived from the eruption of A. D. 79; D. Beds of late Tertiary period containing shells existing at present in the Mediterranean; E. Basis, consisting of denuded surface of Apennine limestone (cretaceous?); F. Chimney or vent.

conclude that the inner or chimney side would be much the same. This, however, is not generally the case, the inner retaining a greater slope than the outer. It is due chiefly to the fusion, or cementing together, of the fragments by the intense heat and the presence of lava, which, so to speak, solders each mass to its neighbor. Each is retained in position by the fluid column occupying the internal cavity, and when this has disappeared the temperature is necessarily lowered, and thus there is formed a lining to the tube by the semifusion of its superficial components. Nevertheless, the upper edges crumble away, falling into the vents, thence to be again ejected. This process continually repeated will result in the majority of the lapilli falling on the outer slope, leaving the chimney of the form of a true funnel, that is to say, a cavity whose sides descend for a certain distance at a moderate angle, say roughly 45°, and then suddenly increasing to nearly a perpendicular. The consequence of this is, a basin-like cavity of sloping walls, with the volcanic vent situated at its center. The materials now ejected by the volcano, supposing it to be in a comparatively quiescent state, will tend to build up a fresh cone occupying this basin. It is not a thing unknown for such a concentric arrangement of cones and craters to be extended to many repetitions. Let us take for example the crater of Somma (Fig. 1) occupied by the cone of Vesuvius, and this again inclosing within its own walls the little cone of eruption, A. We may perhaps represent it thus: A : B : : B : C.

Such a repetition is recorded as being quadruple, thus giving to the mountain, near its apex, a step-like appearance.

From various irregularities and accidents, the vent may shift its position and become eccentric, and thus produce an overlapping of the newer cone upon the older. This is well illustrated by the Island of Vulcano at this moment. In fact, the little hill of scoria surrounding the active bocca or mouth of Vesuvius is situated right away to the east-northeast of the crater, and consequently the lava-streams are more abundant on that side of the mountain (Fig. 2).

The escape of the lava and vapor is the next thing to require our attention. Little more, however, has to be said. The lava rarely mounts the edge of the cone of eruption, generally escaping near its foot, by forcing itself a passage through the loose materials or some preëxisting fissure according to hydrostatical laws. The vapor is the real agent in keeping a vent clear, as the vast bubbles rise through the viscid mass, bursting at its surface, thus keeping up the temperature of the lava-column which it has traversed by the heat brought up from below, and at the same time preventing any permanent stagnation therein. The vapor is generally to be seen carried away by the wind in beautiful white clouds. When, however, the eruption is of a more intense kind, these vast volumes mount into the air at great heights, appearing like a column of fire by night, carrying with them lapilli and ash often thousands of feet above the mouth of the volcano;

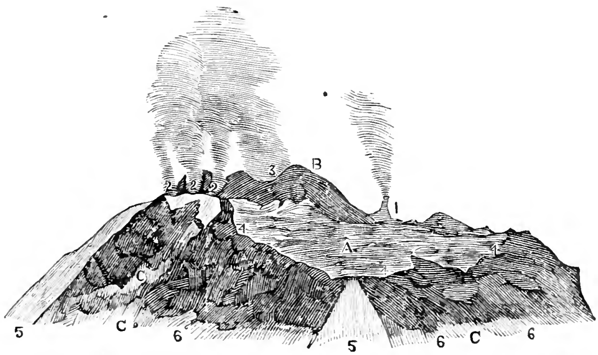


FIG. 2.—VIEW OF THE CRATER OF VESUVIUS, AS SEEN FROM THE HIGHEST POINT OF MONTE SOMMA, ON JULY 1, 1880: A. Crater; B. Cone of eruption; C. Slopes of cone. 1. Spire-like fumarole; 2. Irregular fumaroles along a fissure; 3. Bocca-Grande, or vent; 4. Edges and walls of crater (full); 5. Ash-beds composing cone; 6. Cooled lava-streams all thrown out since November, 1879.

then, suddenly spreading out, these vast clouds give rise to the well-known appearance of the Italian pine-tree. At the same time, from every available fissure are seen to issue little columns of vapor, adding their small share to the grandest visible display of force that Nature has provided for our amusement or peril.

This brings us to the next point of interest, the formation of fumaroles, which may be considered as the effect of these two agents

last spoken of acting together. In Fig. 2 are seen two varieties, one assuming a spire-like form. These may make their appearance anywhere on the volcano, but are usually situated in close proximity to the vent. Their size varies from twelve inches in height upward; generally from three to thirty feet. They are commenced in the major number of cases in the fissured crust recently formed over still-flowing lava. Here the vapor escapes in spasmodic puffs, and by its force a small quantity of lava is forced up and spread out around the aperture, which rapidly cools. It is followed by another puff and another oozing of lava above and around the aperture of the first. In this manner layer by layer is built up, thus giving an irregular, imbricated, roll-like appearance to the exterior. The surface is rapidly covered by brilliantly-colored sublimates, and the fumarole then presents a very pretty spectacle. The author lately was able to thoroughly watch the formation of such a fumarole some twenty feet high, its decadence and disintegration extending over a period of eight months. On passing the arm down the central tube (i. e., the fumarole was extinct), it could be felt very regular and smooth, and having a pretty uniform bore of about nine inches.

After one slight eruption, the fumarole in question presented a very curious phenomenon. Immediately (about two or three seconds) after the explosion from the main vent, there came three terrific bangs, with a spout of vapor from its apex, the last one shooting out small fragments of still liquid lava.

This continued without variation for six hours that the author remained in the crater. The spire-like form may be varied according to

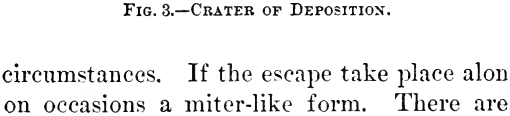


Fig. 3.—Crater of Deposition.

surrounding circumstances. If the escape take place along a fissure, it will assume on occasions a miter-like form. There are many other varieties in form, depending on the variability of surrounding circumstances.

It is now necessary to draw attention to the great difference of opinion which has been expressed upon a point for which we have very little data to support either of two views of the question.

Vulcanologists were for a long time divided into two schools, which often waged war against each other with considerable fierceness. The so-called *upheavalists* were led by such eminent men as Von Buch, Elie de Beaumont, and Humboldt; whereas those who held the

opposite view, which will be immediately explained, claimed as their adherents Sir Charles Lyell, Poulett Scrope, and others.

In Figs. 3 and 4 are diagrammatic representations of the two theories.

The upheavalists believed that the earth-crust actually surrounding the vent was bodily lifted up by the subterranean igneous forces into a dome-shaped or bubble-like mass, thus forming the main mass of the

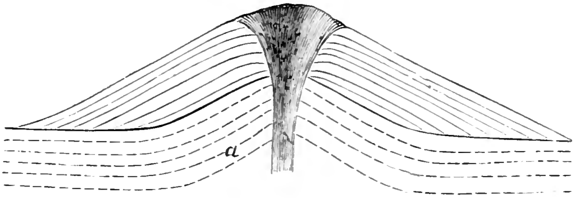


FIG. 4.—CRATER OF UPHEAVAL.

cone, of which the center was the point of fracture, and therefore the vent. The ejecta were therefore considered to form only a thin superficial crust covering this. The subjacent rock which had been elevated would thus have a quaquaversal or periclinal dip away on all sides from the chimney (Fig. 4).

The opponents to this view attribute the entire bulk of the mountain to the ejecta, as seen in Fig. 3, the only change in the basement beds being those produced by pressure and excavation, both of which tend to make them dip toward the vent, thus producing quite a converse effect to the former.

This latter view certainly seems the most feasible, and, after a careful examination of many of the old craters brought forward by the upheavalists as evidence, one becomes satisfied that they have wrongly interpreted facts, which the more advanced state of knowledge at the present day and the collected experience of subsequent observers make easy to our perception. On the other hand, it would be undoubtedly rash to conclude that all craters were formed entirely on one or the other model. Jorullo, in Mexico, for instance, has many points about it to support the upheaval theory. David Forbes, that clear observer, mentions many facts about South American volcanoes that should deter us from admitting the formation of cones and craters by the deposition of ejecta only.

The rapidity with which a volcanic cone may be raised is a point of great interest. We hear every now and then of some small island appearing and again disappearing below the sea almost as rapidly as it rose. Probably, however, the best illustration is that of Monte Nuovo, four hundred and fifty-six feet high, situated in the Campi Phlegraei, about eight miles west of Naples. This was raised from a

marshy plain almost level with the sea in about four days, commencing on September 30, 1538.

The whole hill is, therefore, the product of one eruption. It is an interesting fact that no stream of lava was developed. It would seem that the explosions were so intense that the fluid rock was entirely broken up and ejected in a fragmentary condition, of which there are great quantities forming the slopes.

The cone of Vesuvius proper, fifteen hundred feet high above the lowest edge of the crater of Somma, has entirely been built up of the ejecta thrown out at the time of and since the memorable eruption of A. D. 79, in which Herculaneum, Pompeii, Stabia, etc., were destroyed. Besides the bulk of the mountain now seen, we must not forget the vast quantity that has been required to fill up the crater of Somma, much enlarged by the eruption spoken of. It is said that no lava ran from Vesuvius till the tenth century; this probably would be explained by the fact that all the earlier streams were occupied in filling up the great crater.—*Science-Gossip.*

EYES AND SCHOOL-BOOKS.

By Professor HERMANN COHN.

IT was formerly considered, and some recent text-books have repeated the error, that the qualities of near-sighted and long-sighted eyes were opposed. The investigations of Professor Donders, of Utrecht, have, however, shown that not only is long-sightedness not the opposite of near-sightedness, but that the two defects may be associated in the same individual. The real opposite of short-sightedness, according to Professor Donders, is over-sightedness. He distinguishes three kinds of eyes: 1. Those whose axis is of the proper length from front to rear, normal-sighted or emmetropic (*ἐν μέτρῳ ὤψ, seeing at the right distance*); 2. Those whose axis is too long, short-sighted, or myopic (from *μύειν, to blink*, from the habit common to near-sighted persons of partly closing the eyelids in looking at distant objects); and, 3. Those whose axis is too short, over-sighted, or hypermetropic, *seeing beyond the measure.* To see at a distance, the emmetrope needs no glass, the myope a concave glass, the hyperope a convex glass.

All three kinds of eyes may become far-sighted or old-sighted as their near vision becomes weaker in old age. This kind of far-sightedness is no more a disease than the turning gray of the hair; it depends upon the diminished force of the muscle that curves the crystalline lens for near vision.

Myopy is seldom congenital. All experts remark that it is rarely found in children of less than five years of age. All agree likewise that it arises from a too steady application of the eyes to close objects, especially during the school age. The attention of the authorities in Baden was directed to this fact forty years ago, by the number of students in the gymnasia who wore spectacles. Their inquiries were followed up by Dr. Szokalsky in Paris. Professor C. von Jäger, of Vienna, in 1861, was the first person who made a systematic examination of the eyes of children in reference to this point. Out of two hundred children, he found fifty-five per cent. of those in an orphan house, and eighty per cent. of the pupils in a private school, to be short-sighted. He did not, however, consider his investigation extended enough to justify his drawing a general conclusion.

I began in 1865 to examine the school-children of my native city, and believed, after I had gone through thirty-three schools of all grades, up to the gymnasium, containing 10,060 children, that I was justified in announcing the three following laws: 1. Short-sightedness hardly exists in the village schools—the number of cases increases steadily with the increasing demands which the schools make upon the eyes, and reaches the highest point in the gymnasia; 2. The number of short-sighted scholars rises regularly from the lowest to the highest classes in all institutions; 3. The average degree of myopy increases from class to class—that is, the short-sighted become more so.

My investigations have been repeated in many cities of Europe and America, and my conclusions have been everywhere confirmed. I may cite the examinations of Dr. Thilenius at Rostock in 1868; of Dr. Schultz at Upsala in 1870; of Dr. Crismann at St. Petersburg, and Dr. Maklakoff at Moscow, in 1871; of Dr. Krüger at Frankfort, and Herr von Hoffmann at Wiesbaden, in 1873; of Dr. A. von Reuss in Vienna, Dr. Ott and Dr. Ritzmann in Shaffhausen, Dr. Burgl in Munich, and Professor Dor in Bern, in 1874; of Dr. Conrad in Königsberg in 1875, of Dr. Scheiding in Erlangen, Dr. Koppe in Dorpat, Professor Pflüger in Lucerne, and Drs. Loring and Derby in New York, in 1876; of Dr. Emmert in Bern, Drs. Kotelmann and Classen in Hamburg, Professor Becker in Heidelberg, Drs. William, Agnew, and Derby, in Cincinnati, New York, and Boston, in 1877; Dr. Niemann in Magdeburg, Dr. Seggle in Munich, Professor Dor in Lyons, Dr. Haenel in Dresden, and Dr. Reich in Tiflis, in 1878; Dr. Just in Zittau, and Dr. Florschutz in Coburg, in 1879. We have in all more than thirty accurate reports of competent oculists, giving the results of the most careful investigations among more than forty thousand scholars.

The final results of all these observations, when combined, show that in the village schools hardly one per cent., in the elementary schools five to eleven per cent., in the girls' schools ten to twenty-four per cent., in the real schools twenty to forty per cent., and in the

gymnasia between thirty and fifty-five per cent. of the pupils are myopic.

University students have so far been examined only in Breslau and Tübingen. I found in 1867 fifty-three per cent. among the Catholic theologues, fifty-five per cent. of the law students, fifty-six per cent. of the medical students, sixty-seven per cent. of the evangelical theologues, and sixty-eight per cent. of the students of philosophy, to be short-sighted. In July, 1880, I again examined our medical students, and found that fifty-two per cent. of those who had not passed the *examen physicum*, and sixty-four per cent. of the candidates who had already stood the examination, were myopic; and I am convinced that the work of preparing for the examination in this as well as in the other departments contributes to the increase of near-sightedness. Dr. Gärtner, between 1861 and 1879, examined six hundred and thirty-four students of the Evangelical Theological Seminary in Tübingen, and found that seventy-nine per cent. of them were myopic.

If we inquire into the bearing of nationality on the development of the affection, we find that in the gymnasia at Upsala thirty-seven per cent., at St. Petersburg thirty-one per cent., at Dorpat fifty-five per cent., at Lyons twenty-two per cent., at Tiflis thirty-seven per cent., at New York twenty-seven per cent., at Boston twenty-eight per cent., of the students are myopic. In the gymnasia of St. Petersburg thirty-four per cent. of the Russian, and only twenty-four per cent. of the German scholars; at Tiflis, thirty per cent. of the Russians, thirty-eight per cent. of the Armenians, and forty-five per cent. of the Georgians, were short-sighted. Of five hundred and twenty-nine teachers in Lucerne, fourteen per cent. of the Latin Swiss, twenty-four per cent. of the German Swiss, were affected. Loring and Derby observed in New York, in 1876, that fourteen per cent. of the children of Irish, twenty per cent. of American, and twenty-four per cent. of German parents, were near-sighted. At the International Congress of Physicians, held in Paris in 1867, I confidently addressed every one who wore spectacles in German, and was sure to receive a German answer. It is possible that the Germans have become more than ordinarily predisposed to short-sightedness, by the operation of compulsory education through several generations; but this can not yet be taken for granted, for relatively only a small proportion of non-German school children have been examined. The statements of all the authorities establish, however, that everywhere, and in all institutions, the number of myopes increases from class to class, and becomes really formidable in the secunda and prima of the gymnasia and real schools, and the corresponding classes of other schools. It ranges at between thirty-five and sixty per cent. of the whole number of scholars; but the proportion has been found to exceed sixty per cent. in the prima of several German gymnasia, and to rise to eighty per cent. at Erlangen, and one hundred per cent. at Heidelberg. Taking the

average of the results of the examinations in twenty-five German and Swiss gymnasia with 9,096 scholars, the percentage of short-sighted pupils rose from the sexta to the prima as follows : 22, 27, 33, 46, 52, 53.

These numbers speak plainly enough. Still there are persons who doubt that children become short-sighted at school. In order to make this more clear, I examined the pupils of the Friedrichs Gymnasium at Breslau in 1871, and repeated the examinations upon the same persons three semesters afterward. Seventeen pupils who had been found normal-sighted at the first examination had become short-sighted, and more than half of those who had appeared near-sighted at first had become more so. Similar results have been obtained by Dr. A. von Reuss in the Leopold Stadt Gymnasium at Vienna, by Dr. Seggle in the Cadet Corps at Munich, and by Dr. Derby at Boston.

It is evident that we are threatened with a great national affliction, which is likely not only to be detrimental to all peaceful occupations, but to impair the military efficiency of our people. It is important to seek out the causes of this ever-growing evil and contest them with energy. We can not discuss here all the causes that tend to produce myopy. All protracted looking at close objects may contribute to it. Among the more active causes may be mentioned badly-constructed school-benches, imperfect lighting, too much reading, bad writing, and bad type. The matter of the style of typography which is most compatible with the preservation of the eyesight deserves especial consideration. The most important point is the size of the letters. We can not determine this by the measurement of the *em*, as the printers do, for that regards the shank of the type, of which readers know nothing ; but it must be judged by a special measurement of the visible letter. I have adopted as the standard of measurement the letter *n*, that being the most regular and symmetrical in shape in both the Roman and German alphabets. I have found that the *n* in pearl type is about 0·75 millimetre (or about $\frac{3}{100}$ of an inch) high, in nonpareil 1 millimetre (or about $\frac{1}{25}$ of an inch), in brevier (petitschrift) $1\frac{1}{4}$ millimetre (or about $\frac{1}{20}$ of an inch), in long primer (corpusschrift) $1\frac{1}{2}$ millimetre ($\frac{1}{17}$ inch), and in pica (Ciceroschrift) $1\frac{3}{4}$ millimetre ($\frac{1}{14}$ inch).

We have hitherto had no definite rules concerning the smallest size of letters which should be permitted for the sake of the eyes. The distance at which a letter of any particular size can be seen does not afford a guide to it, for it does not correspond at all with the distance at which matter printed in the same type can be read steadily, at the usual distance in reading. I believe that letters which are less than a millimetre and a half ($\frac{1}{17}$ inch) high, will finally prove injurious to the eye. How little attention has hitherto been paid to this important subject is exemplified in the fact that even oculistic journals and books

frequently contain nonpareil, or letters only a millimetre ($\frac{1}{25}$ inch) high.

Many of the text-books required by the school authorities are badly printed. The officers should go through every school-book with a millimetre-rule in their hands, and throw out all in which the letters are less than a millimetre and a half high, and should give the preference to those establishments which do not use letters of less than two millimetres ($\frac{1}{13}$ inch).

The distance between the lines is an important factor in respect to ease in reading. As is well known, the compositors often insert thin leads between the lines so that the letters which project above the average height and those that fall below the line shall not touch. Every one knows that legibility is improved by contrast; the darker the print and the clearer the paper, so much easier is the reading. When the lines are close together, or the matter is printed "solid," the eyes become tired sooner, because the contrast is lessened. The lines tend to run together, and the effort to separate them strains the eyes. In fine editions the lines are widely separated. I consider a book well leaded in which the interlinear space, measured by the shorter letters, amounts to three millimetres ($\frac{1}{8}$ inch). The lines will really seem to be closer, for the projections of the longer letters will encroach upon the interlinear space; and cases may occur, when those letters predominate, in which the space may seem to be only one millimetre. The narrowest interval that should be permitted is, in my opinion, two and a half millimetres ($\frac{1}{10}$ inch).

The thickness of the strokes should also be regarded, for it is obvious that the form of the letter is more readily and more clearly impressed on the retina when the stroke is broad and distinct than when it is fine. Letters having a stroke of less than one fourth of a millimetre ($\frac{1}{100}$ of an inch), in thickness should not be admitted into school-books. Ample space should be allowed between the letters. Laboulaye recommended that every two letters should be separated by a clear space at least as broad as the distance between the two strokes of the *n*.

Javal believes that the extension of the lines beyond a certain limit of length contributes to myopy, by forcing the eye to endeavor to adjust itself to the varying distances from the eye of the ends and the middle of the line. This has not been demonstrated, but it is not improbable. Every near-sighted person is aware of the pain it occasions him to read a number of long lines without spectacles. The shorter the lines, the more easily they are read, because the eye does not have to make wide excursions. The most suitable length of lines for school-books appears to be about ninety millimetres, or three and a half inches.

Javal has observed that the rectangular Roman letters are liable to be reduced in apparent size, and have their corners seem rounded by

irradiation from the white paper, and recommends a thickening of the cross-strokes at the ends to obviate this defect. This observation is less applicable to the German letters, for they already have broken lines and knobbed expansions at the ends of the strokes. Many physicians, particularly those who are not Germans, believe that the shape of the German letters is more tiresome to the eyes than that of the Roman letters. I have never been able to perceive this, nor any reason why it should be so, provided the German print is large and thick enough, and the lines are far enough apart. Use has doubtless much to do with the matter. For myself, it is always pleasant, after a long reading of the monotonous Roman print, to return to "our beloved German."

Even the thickest and largest letters, the shortest and best separated lines, and the most excellent printing, may speed the progress of myopy if the light is bad. At home, every one can find a light place to read—by the window on dark days, by a bright lamp at night. It is different in schools and offices. Fifteen years ago, after measuring the ratio of the window-space to the floor-space in the schoolhouses of Breslau, I declared that there could never be too much light in a schoolroom, and estimated that unless the house could be furnished with a glass roof, at least thirty square inches of window-space should be provided for each square foot of floor-space. In many schoolrooms as at present arranged, the pupils nearest the windows may be sitting in a glare of light, while those farthest away are not able to study for the obscurity. Notwithstanding all that has been written and all that has been done in the last fifteen years for the improvement of schoolrooms, enough is still left to be done in nearly every town.—*Deutsche Rundschau.*

DEEP-SEA INVESTIGATION.*

By J. G. BUCHANAN, F. R. S. E.,
OF THE CHALLENGER EXPEDITION.

THE first problem of deep-sea investigation is to determine the extent of the ocean, its size, its volume. The superficial extent and limits are determined by the surveyor. In order to map out the bottom of the sea, there is only one method, namely, the direct determination of the depth at as many places as possible. When a ship is "in soundings," the depth is ascertained by the ordinary hand lead-line, which is from twenty to twenty-five fathoms long, and is conventionally marked at stated intervals with bits of leather, white,

* Abridged and condensed from an address delivered before the Society of Arts, February 24, 1881.

red, and blue bunting, and knots. The lead is a long, finely-tempered block, generally weighing fourteen pounds, which has a recess at the thick end, and is perforated at the other end for the reception of the line. This instrument is chiefly used while the vessel is in motion. The leadsman swings the lead vigorously, so as to give it momentum enough to carry it well in advance of the ship before it touches the water. It sinks rapidly while the leadsman's position is advancing to the spot where it touched the water. The depth is ascertained by looking at the marks on the line. This method is effective and correct enough for ordinary purposes, in depths of not more than twelve or fifteen fathoms. Accurate soundings may be obtained by reducing the speed of the vessel as much as possible, in depths which do not much exceed thirty or forty fathoms. In ocean-water, where depths of two or three thousand fathoms are met, the vessel must be kept stationary, and heavier weights than are found sufficient for shallow soundings must be employed.

Deep-sea soundings have received much attention during the last thirty years. The first attempt at them appears to have been made by Captain Constantine John Phipps, during his Arctic Expedition in 1773. He sounded a depth of six hundred and eighty-three fathoms with a lead weighing one hundred and fifty pounds, which appears to have sunk about ten feet into the mud. Determinations of the temperature of the sea water and of its density were made at the same time. Captain John Ross employed, during his Arctic voyage of 1818, one of the earliest satisfactory instruments for bringing up a considerable quantity of the bottom mud in deep water, with which he was able to ascertain the temperature at any depth.

A contemporary of Ross, the younger Scoresby, observed that, when in sounding at great depths the ordinary deep-sea line and lead are used, the increasing weight of line, in proportion as more of it is required, renders less certain the determination of the moment when bottom is reached. He has also left the record of the first observation of the effects of the enormous pressure which is acting under the deep waters. The Americans have introduced the method of using fine twine and a heavy weight, both of which may be sacrificed at every sounding, to obviate the inconveniences arising from overweight of rope. The practice of observing the rate at which successive equal lengths of line pass out has been found useful in cases where ordinary observation or feeling does not suffice to indicate when the shot has reached the bottom. Iron wire was first used instead of twine about 1850, by Lieutenant Walsh, of the United States schooner Taney.

When the surveys for telegraphic cables were begun, it became important to ascertain the nature of the ground at the bottom. The apparatus invented by Midshipman Burke, of the United States Navy, in 1854, answered this purpose. It consisted of a cannon-ball with a hole drilled through it. Through this hole passed a straight rod,

fitted at its upper end with peculiar disengaging hooks. The weight was slung to these hooks by means of a wire which passed from a ring slipped over the rod under the weight, up on each side of the cannon-ball to the hooks. The sounding-line was attached to eyes in these hooks, and, as long as the lower end of the rod was not resting on anything, the weight was kept securely in its place, and was available for taking out the sounding-line. As soon, however, as bottom was reached, and the rod came to be supported on its lower end, the hooks at the upper end fell forward, and allowed the wire to disengage itself. The weight was thus released, and, on the line being pulled up, the rod came away through the perforation of the shot, and brought with it specimens of the mud in small quill tubes fitted in a recess in the lower end of the rod. This apparatus has been improved by substituting a tube for the rod, and so arranging the attachment of the weight that it shall continue till the hauling in is begun, whereby its mass and momentum are available for forcing the tube as deep into the ground as possible. Captain Shortland devised another modification of the apparatus in 1868, for the soundings between Bombay and Aden. The essential part was the insertion of two butterfly valves in the lower end, and two conical valves opening upward in the middle of the tube, between which a sample of the bottom water is secured, while a specimen of the mud is brought up in the lower segment of the tube. It was used with general satisfaction during the first year of the cruise of the Challenger. The chief objection to it was founded on the smallness of the samples of bottom which it brought up. This machine, the "Hydra," was replaced after the first year by the "Bailey," an apparatus having a larger tube fitted to bring up more considerable samples of mud.

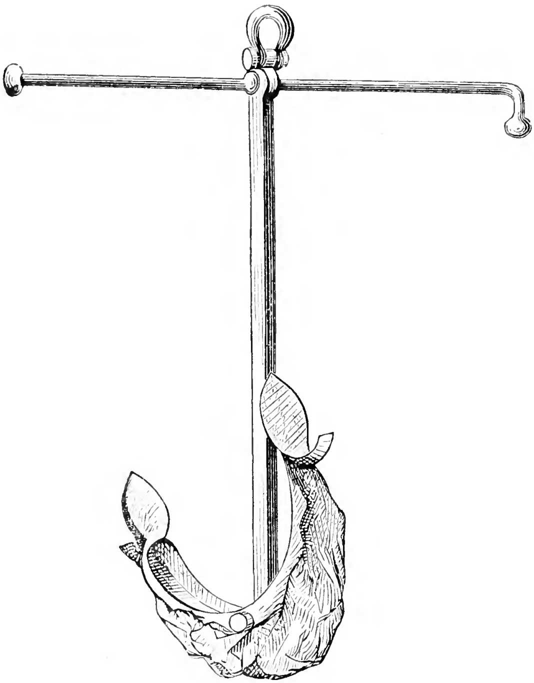
An apparatus which the author has devised for sounding the Scottish lakes, and found to act well, consists of a straight brass tube an inch in diameter, carrying a shoulder about one foot from the lower end. A cylindrical leaden sinker of suitable weight is slipped over the upper end, and rests on the shoulder. The line is made fast to an eye at the top of the tube, and the part of the tube below the shoulder can be unscrewed, and the mud which it has brought up squeezed out. The tubes bury themselves readily in soft mud and clay, and bring up considerable samples.

It is necessary, in making a sounding in deep water, to load the end of the line with such a weight that in the deepest water that may be reasonably expected the velocity of descent shall not be diminished to an excessive extent by the friction of the increasing length of line in passing through the water. Wire has been largely employed for the line, and has great advantages in this respect over hemp. For example, in water of fifteen hundred fathoms a sinker weighing three hundred-weight is twenty minutes in reaching the bottom, with the best hempen sounding-line; while with wire and a sinker of thirty

pounds the sounding may be completed in from twenty-five to thirty minutes. Wire, however, is less flexible than hemp, and breaks under the influence of kinks and twists, which do not affect the strength of hemp in any degree. The balance of advantages is in favor of wire, but it is well to have ropes of both kinds.

The anchor used by the author for holding his vessel in place, during his explorations on the west coast of Scotland during the summer of 1878, brought up so many fine specimens from the mud in which it

Fig. 1.



sank before taking hold on the bottom, that he determined to provide himself with one which should retain the mud. For this purpose he had an anchor made with an open frame, instead of a solid bar connecting the two palms, to which was laced a stout canvas bag, into which any mud sticking to the palm at the moment of its breaking out of the ground would fall (Fig. 1). The instrument proved a useful one for exploring the bottom, particularly when the object was to collect the mud itself rather than the things living on its surface, and was, moreover, efficient as an ordinary kedge-anchor.

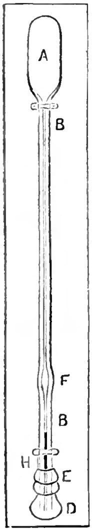
Doubts have sometimes been thrown on the trustworthiness of deep soundings with the line and heavy sinker. First, it was asserted that under some great pressure the density of water would become

equal to that of lead, and the sinkers would float instead of sinking. This might be the case were water as compressible as air, and if the lead could escape compression; but the amount of pressure that will double the density of air will increase that of water by only one-twenty-thousandth part, and it would require the pressure of more than two hundred thousand atmospheres to squeeze water to the density of lead. The deepest water, five thousand fathoms, is not subject to a pressure that can raise its density as much as one-twentieth part. Moreover, the weight of lead is increased by pressure much faster than that of water, so that, however dense the water may be, it would have to encounter a still denser lead. This objection, however, fallacious as it has been shown to be, has been admitted by persons of high authority, of course without sufficient thought.

A more real but exaggerated objection to the trustworthiness of deep soundings is founded on the existence of currents likely to cause deviations in the direction of the line, and to change the position of the ship. There is no doubt concerning surface-currents; they are observed and measured every day, and form an important factor in the navigator's daily reckoning. It has been inferred that they may be complemented by return under-currents which will be harder to deal with because they can not be so easily detected and measured. Soundings taken in the presence of such currents are, it must be admitted, less to be relied upon than those taken in manifestly quiet waters; but the extent of under-currents has been very much exaggerated. By far the greater part of the ocean is, for sounding purposes, practically still water. The surface-currents of any importance are easily recognized, and so also are the under-currents. Just as a physician can, by bringing his experience to bear on the sounds transmitted to him by the stethoscope, divine what is taking place inside the body of his patient, so the experienced seaman can, by observing the behavior of his sounding-line, form a fair diagnosis of what is taking place in the depths of the sea. When the sinker passes into a belt of under-current, the fact is very soon apparent; but, even with the greatest care, soundings taken under such circumstances are of doubtful value, unless bottom is brought up. In the latter case, we know the depth is not greater than the length of line used, and a correction, suggested by observation and experience, may be applied, which will bring our estimate of the depth very near the truth. It is evident that this can not be satisfactorily done by the sounding-line alone, and it early occurred to those who thought on the subject that the method which promised most success was that which should give the depth in terms of the height of the column of water; in other words, the barometrical measurement of altitudes was extended from the land to the sea. The instruments which have been suggested for this purpose are constructed with a view to record the amount of compression produced on a given mass of a certain elastic substance.

From the known law regulating the variation in volume of the substance with variation in the pressure, the maximum pressure to which the instrument has been exposed can be deduced, and from the known density of the water the height of the column of it which would produce that amount of pressure can be calculated ; this height represents the depth to which the instrument has been sunk. Perkins, about 1812, constructed a piezometer, or instrument for measuring pressure, consisting of a glass tube sealed at one end, filled with water, and inverted in a cup of mercury. A steel index placed within the tube rose with the mercury, and was retained by a spring at the highest point reached. Instruments made on this principle were used by him, by Aimé in the Mediterranean, in 1848, and by the United States Coast Survey a few years later. Essentially the same instrument, with certain convenient practical modifications, was used by the author in the Challenger Expedition.

Fig. 2.



Another method of measuring the pressure, and through it the depth, of the sea, is by means of an instrument (Fig. 2) much resembling in principle the aneroid barometer. Its simplest form is that usually given to a mercurial thermometer. When the pressure on the outside of the instrument is increased, the bulb tends to collapse, and, flattening, to force the mercury into the stem. The amount of compression may be shown as before by an index on the column of mercury. The use of mercury in this instrument is, however, unsatisfactory, because its contraction under the diminished temperature of the lower depths tends to counteract the effect of pressure in pushing it forward. It is, nevertheless, adapted to waters of a uniform temperature, as in the polar regions.

Soundings from vessels in motion may be taken with Massey's machine, in which the friction of the passing water as it sinks causes a screw-fan to make rotations which are registered by an index. Sir William Thomson has proposed the use of a glass tube, sealed at one end, and coated internally with a chemical preparation, the color of which is changed by the action of sea-water. The sea-water forces itself in as the tube sinks, changing the color of the coating to an extent from which the depth may be calculated. Each of these instruments is good for only one sounding.

The author has patented a device by which the depth of compression to which an inclosed mass of air has been subjected is measured by the water which has gained admittance to the instrument. It is represented in Fig. 3. It consists of a glass tube open at both ends, but capable of being closed by a stopper or other means. At some part of the tube a spout is introduced, and the tube is bent over through two right angles immediately above it. When the

instrument is to be used, the end is closed, and the line let go; when bottom has been reached it is brought up again, and we find that a certain amount of water has lodged in the lower part of the tube. It is evident that, as the instrument descends and the air in it is compressed, the water forces its way in through an orifice, and past the spout. This spout is so formed that it delivers the water against the walls of the tube, down which it runs, and collects at the bottom. When the motion of ascent begins, the air, by its elasticity, tends to recover its original volume, and expands in the direction of greatest freedom. Now, all the water which has entered has collected below the spout; consequently, in reëxpanding, this water will be left undisturbed.

FIG. 3.

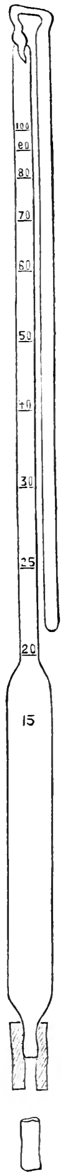
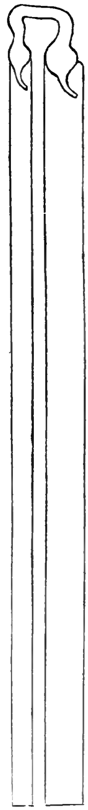


FIG. 4.



Assuming that the volume of the mass of air in the instrument varies inversely with the pressure to which it is subjected, we require, in order to be able to construct a scale for our instrument, and so to interpret its results, to know the total volume of the tube, the volume of the part which I call the vestibule, the dimensions and volume of the narrow tube, and of the wide one.

Fig. 4 represents an instrument modified so that it can be used either for great or small depths, according as either end is closed. Mr. Hunt, of the United States Coast Survey, has invented an apparatus consisting of an air-tight bag, made of flexible material, with a long, flexible tube attached to it. The bag, being filled with air, is sunk to the bottom (in a moderate depth of water), while the other end of the flexible tube is connected with a Bourdon's pressure-gauge in the ship or boat, the observation of which gives an exact profile of the bottom as the bag is towed over it.

Bottom temperatures may be measured by common thermometers protected so as to be uninfluenced in coming up through the warmer upper strata of water, by bringing the water to the surface and taking its temperature, or by self-registering thermometers, such as Cavendish's and Six's. A great amount of ingenuity has been displayed in the invention of machines for registering the actual temperature of the water at any given depth, independently of that of the water above it, all of which require some assistance from

the observer in bringing about a catastrophe which shall leave its mark on the condition of the instrument.

All the self-registering thermometers are liable to error from the effects of pressure, which may amount to five or six hundred atmospheres on the outside of the instrument, while inside it is never greater than was that of the atmosphere when the tube was sealed up. Attempts to obviate them have been made by placing the thermometers or their bulbs in protecting inclosures, and by the device of leaving the instrument open at one end. This was adopted by Aimé in some of his experiments, when the effect of pressure on the apparent volume of the liquid was determined independently, and a correction applied accordingly. The author has devised and constructed a mercurial thermometer, or piezometer (Fig. 5) on the same principle, but his object in admitting the water-pressure to the inside of the instrument was to utilize it in shifting the scale of the thermometer as the depths changed. The thing registered in such instruments is always the apparent volume of the liquid, and this varies with the temperature and the pressure. Hence the indications will represent the sum of the effects of the change of temperature and of pressure. If from any independent source we know either of these, we can determine the other. In a sea of uniform temperature throughout its depth, the apparent volume of the liquid would diminish as the pressure increased, and, if the temperature increased with the depth, the apparent volume of the liquid would diminish at a slower rate; but it would be always possible to determine the true temperature as long as it did not increase at so great a rate as to dilate the liquid more than it was compressed by the increasing pressure. For the investigation of seas such as the Mediterranean, this form of instrument is most valuable. No one instrument, however, fulfills all the conditions required of a perfect deep-sea thermometer, and the investigator must use his judgment in selecting the one or more best suited to his particular purpose.

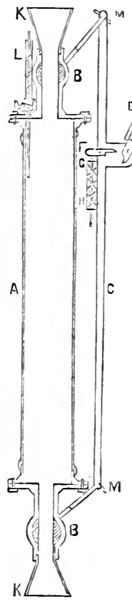
Fig. 5.

The water from the bottom is usually collected in the so-called "slip" water-bottle. Water from intermediate depths is obtained in an instrument represented in section in Fig. 6. It consists of a cylinder, A, terminated at both ends by similar stopcocks, B, B, which are connected by the rod C. This rod carries, near its upper extremity, a piece of stout sheet-brass, D, ten centimetres long by fifteen broad, soldered to the casting E, which is movable about the axis *e*.

When intermediate water is to be obtained, the water-bottle is firmly attached to the sounding-line, which carries at its end usually a fifty-six pound or one hundred-weight lead; the stopcocks are then opened, giving them, with the rod C, the position represented in the figure. During the passage of the bottle downward, the water

courses freely through it, being considerably assisted by the conical end-pieces K K. When the requisite depth is reached, the line is checked and is finally hauled in. Under the pressure of the hauling, the flap D falls down into an horizontal position, when it is caught by the movable piece of brass F, which moves round an axis, *f*, and is supported on the side opposite to E by the rod G, which rests on the spiral spring H. The water rushing past D, when thus in an horizontal position, exercises a sufficient pressure upon the rod to close the stopcocks B, B. When the speed with which the bottle is hauled through the water is increased, the pressure on D becomes so great that it overcomes the tension of the spring H, and E passes the catch F, when the rest of the journey upward is performed with the flap D hanging down, and therefore offering the least possible resistance to the water. When the water-bottle has been brought up, it is only necessary to substitute for the lower funnel a small nozzle, by which the water may be drawn off, and the instrument be made ready for immediate use without having to detach it. It has been ascertained by experiment that the water obtained by this instrument is an average of the last two fathoms through which it has passed.

FIG. 6.



THE WILL-O'-THE-WISP AND ITS FOLK-LORE.

BY T. F. THISELTON DYER.

AMONG the many sources of superstition in this and other countries, the phenomenon well known as the Will-o'-the-Wisp has from time immemorial held a prominent place. Indeed, it would be no easy task to enumerate the various shapes in which the imagination has pictured this mysterious appearance, not to mention the manifold legends that have clustered round it. In days gone by, when our credulous forefathers believed in the intervention of fairies in human affairs, the Will-o'the-Wisp entered largely into their notions respecting the agency of these little beings in their dealings with mankind; and, as will be seen in the course of the present paper, numerous stories were often related in which some fairy disguised as Will-o'-the-Wisp was the chief character. It is worthy, too, of note that, although in these enlightened days every relic of primitive culture is gradually fading from our gaze, the old superstitious fancies associated with this nocturnal visitor still survive with more or less vigor, retaining that hold on the vulgar mind which they formerly possessed.

Thus, in remote villages and secluded country nooks the peasant, while not forgetting the traditions handed down to him, continues to believe with implicit faith in those quaint and weird fancies which have invested the Will-o'-the-Wisp with such a peculiar dread. This terror, as we shall point out, in a great measure originated in the many tales and legends that were in past centuries framed to explain and account for this deceptive phenomenon.

Referring, then, in the first place, to the various names assigned to it—many of these are extremely curious, differing according to the country and locality. Its most popular appellation, Will-o'-the-Wisp, was probably derived from its customary appearance; this wandering meteor having been personified because it looked to the spectators like a person carrying a lighted straw torch in his hand. Hence it has been termed Jack, Gill, Joan, Will, or Robin, indifferently, in accordance with the fancy of the rustic mind; the supposed spirit of the lamp being thought to resemble either a male or female apparition. Hentzner, for instance, in his "Travels in England" (1598), relates how, returning from Canterbury to Dover, "there were a great many Jack-a-lanthorns, so that we were quite seized with horror and amazement."

In Worcestershire, the phenomenon is termed by the several names of "Hob-and-his-Lanthorn," "Hobany's Lanthorn," and "Hoberdy's Lanthorn"—the word Hob in each case being the same name as occurs in connection with the phrase hobgoblin. It appears that, in days gone by, Hob was a frequent name among common people, and, curiously enough, Coriolanus (Act ii, sc. 3) speaks of it as used by the citizens of Rome:

"Why in this wolvish gown should I stand here,
To beg of Hob and Dick, that do appear
Their needless vouches?"

Subsequently, Hob seems to have been used as a substitute for Hobgoblin, as in Beaumont and Fletcher's "Monsieur Thomas" (Act iv, sc. 6):

"From elves, hobs, and fairies,
From fire-drakes or fiends,
And such as the devil sends,
Defend us, good Heaven!"

A Northamptonshire name is Jinny Buntail, which is evidently a corruption of Jinn with the burnt tail, or "Jild burnt tail," an allusion to which occurs in Gayton's "Notes on Don Quixote" (1654, 97), where we read of "Will with the Wispe, or Gyl burnt tayle," and, again (268), of "An *ignis fatuus*, or exhalation, and Gillon a burnt tayle, or Will with the Wispe." The Somersetshire peasant talks of "Joan-in-the-Wad," and "Jack-a-Wad," Wad and Wisp being synonymous. In Suffolk it was known as "A Gylham lamp," in reference to which we are told in Gough's "Camden" (ii, 90) how, "in the low

grounds at Sylham, just by Wingfield, are the *ignes fatui*, commonly called Sylham lamps, the terror and destruction of travelers, and even of the inhabitants, who are frequently misled by them."

Another of its popular nicknames in former years was "Kit of the Canstick"—i. e., candlestick; and, in "Poor Robin's Almanack" for 1777, it is styled "Peg-a-lantern":

"I should indeed as soon expect
That Peg-a-lantern would direct
Me straightway home on misty night;
As wand'ring stars, quite out of sight,
Pegg's dancing light does oft betray,
And lead her followers astray."

The expression *ignis fatuus*, or foolish fire, originated in its leading men astray, as in the "Tempest" (Act iv, sc. 1), where Stephanio says, "Monster, your fairy, which you say is a harmless fairy, has done little better than played the jack with us"—a passage which is explained by Johnson thus: "He has played Jack-with-a-lantern; he has led us about like an *ignis fatuus*, by which travelers are decoyed into the mire." Thus Gray describes it:

"How Will-a'-Wisp misleads night-gazing clowns
O'er hills, and sinking bogs, and pathless downs."

In Scotland, one of the names for this appearance is "Dank Will," and in Ireland it is known as "Miscann Many," an allusion to which occurs in Croker's "Fairy Legends of the South of Ireland" in the story of the "Spirit Horse," where Morty Sullivan is so sadly deluded by it.

Again, the term "Fire-drake,"* which is jocularly used in "Henry VIII" (Act v, sc. 4) for a man with a red face, was one of the popular names for the Will-o'-the-Wisp; in allusion to which Burton, in his "Anatomie of Melancholy," says, "Fiery spirits or devils are such as commonly work by fire-drakes or *ignes fatui*, which lead men often in *flumina et præcipitia*." It appears, also, that in Shakespeare's day "a walking fire" was another common name for the Will-o'-the-Wisp, to which he probably refers in "King Lear" (Act iv, sc. 3), where, Gloster's torch being seen in the distance, the fool says, "Look, here comes a walking fire"; whereupon Edgar replies: "This is the foul fiend Flibbertigibet; he begins at Curfew and walks till the first cock." Hence Mr. Hunter † considers that Flibbertigibet was a name for the Will-o'-the-Wisp. That, however, this phenomenon was known

* A "Fire-drake" appears to have been also an artificial firework, as in Middleton's "Five Gallants":

". . . But, like firedrakes,
Mounted a little, gave a crack, and fell."

† "New Illustrations of the Life, Studies, and Writings of Shakespeare," ii, 272.

as the "Walking Fire" is evident from the old story "How Robin Goodfellow led a company of Fellowes out of their way":* "A company of young men having been making merry with their sweethearts, were, at their coming home, to come over a heath. Robin Goodfellow, knowing of it, met them, and, to make some pastime, he led them up and down the heath a whole night, so that they could not get out of it; for he went before them in the shape of 'a walking fire,' which they all saw and followed till the day did appear; then Robin left them, and at his departure spake these words:

'Get home, you merry lads,
Tell your mammies and your dads,
And all those that newes desire
How you saw a walking fire;
Wenches that doe smile and lispe
Use to call me Willy Wispe.'"

The Will-o'-the-Wisp is not, it would seem, confined to land, sailors often meeting with it at sea, an elegant description of which is given by Ariel in "The Tempest" (Act i, sc. 2):

". . . Sometimes I'd divide
And burn in many places; on the topmast,
The yards and bowspit; would I flame distinctly,
Then meet and join."

It is called, by the French and Spaniards inhabiting the coasts of the Mediterranean, St. Helene's or St. Telme's fires; by the Italians, the fire of St. Peter and St. Nicholas.† It is also known as the fire of St. Helen, St. Herm, and St. Clare. Whenever it appeared as a single flame it was supposed by the ancients to be Helena, the sister of Castor and Pollux, and to bring ill luck, from the calamities which this lady is known to have caused in the Trojan war. When it came as a double flame, it was called Castor and Pollux, and accounted a good omen. It has also been described as a little blaze of fire, sometimes appearing by night on the tops of soldiers' lances, or at sea on masts and sail-yards, whirling and leaping in the twinkling of an eye from one place to another. According to some, it never appears but after a tempest, and is supposed to lead people to suicide by drowning. Douce,‡ commenting on the passage in "The Tempest" quoted above, thinks that Shakespeare consulted Batman's "Golden Books of the Leaden Goddes," who, speaking of Castor and Pollux, says, "They were figured like two lamps or crescent lights, one on the top of a mast, the other on the stem or foreship." He adds that, if the first light appears on the foreship and ascends upward, it is a sign of good luck; if either light begins at the topmast and descends toward the

* Hazlitt's "Fairy Mythology of Shakespeare," 1875, 186.

† Brand's "Popular Antiquities," 1849, iii, 400, 401.

‡ Douce's "Illustrations of Shakespeare," 1839, 3.

sea, it is a sign of a tempest. In taking, therefore, the latter position, Ariel had fulfilled the commands of Prospero to raise a storm. This, then, coincides with the following lines: *

"Last night I saw Saint Elmo's stars,
 With their glittering lanterns all at play
On the tops of the masts and tips of the spars,
 And I knew we should have foul weather that day."

A curious illustration of this phenomenon is recorded in "Hakluyt's Voyages" (1598, iii, 450): "I do remember that in the great and boisterous storm of this foul weather, in the night there came upon the top of our mainyard and mainmast a certain little light, much like unto the light of a little candle, which the Spaniards call the *Cuerpo Santo.* This light continued aboord our ship about three houres, flying from mast to mast, and from top to top; and sometimes it would be in two or three places at once." This meteor was by some supposed to be a spirit, and by others an exhalation of moist vapors, thought to be engendered by foul and tempestuous weather.

Referring, in the next place, to the legends associated with the Will-o'-the-Wisp, we may mention that these, although differing in many respects, generally invest this strange mimicry in nature with the supernatural element, which is said to be generally exercised for the purpose of deluding, in some way or other, the benighted traveler. Indeed, it would seem that in past centuries whatever phenomena were of an apparently illusive or hostile character were regarded by primitive science as specially designed to work pain or evil, even although, by way of treacherous bait, they might possess the most attractive qualities. Thus, as Mr. Conway has pointed out in his excellent work on "Demonology and Devil Lore" (1880, ii, 212), because many a pilgrim "perished through a confidence in the lake-pictures of the mirage which led to carelessness about economizing his skin of water, the mirage gained its present name—Bahr Sheitan, or Devil's Water." Thus, oftentimes, the harmless and beautiful phenomena in nature have been invested with an evil name, simply because our ancestors, living in the childhood of the world, were unable to comprehend their meaning, and so, in all the freshness of their creative fancy, regarded them as demoniacal agencies to thwart and hinder man's progress in moral culture. Strange, therefore, as it may seem, we in our nineteenth century have in many of the legends that survive in this and other countries relics of Aryan science, which, although meaningless to the casual observer, yet embody the teaching of primitive man.

In this country the Will-o'-the-Wisp has been connected with the fairy race from early times, a fact proved by its old name of Elf-fire. The same notion, too, existed in Germany; for Grimm informs us that it was there formerly known as Elglicht, and in Denmark as Vaettylis.

* Swainson's "Weather Lore," 193.

On this point Mr. Brand* has rightly remarked that the naturalists of the dark ages "owed many obligations to our fairies, for, whatever they found wonderful and could not account for, they easily got rid of by charging to their account. Thus they called those which have since been supposed to have been the heads of arrows or spears, before the use of iron was known, *Elfshots*." In the same way Shakespeare uses the expression "Elfish-marked"; † and also speaks of Elf-locks in "Romeo and Juliet" ‡:

> ". . . This is that very Mab
> That plats the manes of horses in the night
> And bakes the elf-locks in foul sluttish hairs,
> Which, once untangled, much misfortune bodes."

A disease, too, consisting of a hardness of the side was in days gone by termed Elf-cake. Just, then, as the fairies were supposed to be guilty of committing various pranks as seen in the sundry mishaps that befall humanity, so the Will-o'-the-Wisp with its treacherous light was reckoned among them. Thus Shakespeare represents Puck as transforming himself into a fire, by which he clearly alluded to the Will-o'-the-Wisp; and it may be remembered how the fairy asks him— §

> ". . . Are you not he
> That fright the maidens of the villagery,
> Mislead night-wanderers, laughing at their harm?"

We have already noticed, too, Shakespeare's allusion to Ariel's assuming this form, who, like Puck, is a fairy. The term Puck, which is evidently the same as the old word "Pouke," a devil or evil spirit, still survives, although its spelling in lapse of years has become somewhat altered. The following passage from a modern writer ‖ proves, too, that in some places the idea of Puck as a delusive fairy haunting the woods and fields is not yet extinct: "The peasants in certain districts of Worcestershire say that they are sometimes what they call 'Poake-ledden,' that is, they are occasionally waylaid in the night by a mischievous sprite whom they call Poake, who leads them into ditches, bogs, pools, and other such scrapes, often sets up a loud laugh, and leaves them, quite bewildered, in the lurch." This corresponds with what in Devon is called being Pixy-led; and various stories are told how the frolicsome pixies deceive travelers with the Will-o'-the-Wisp, and chuckle over their dismay when they are lost for a time on the moor. By moonlight the Pixy-Monarch was supposed to hold his court, where, like Titania, he gave his subjects their several charges. Some were sent to the mines, where they either good-naturedly led the miner to the richest lode, or maliciously, by noises imitating the stroke of the

* "Popular Antiquities," 1849, ii, 490. † "Richard III," Act i, sc. 3.
‡ "Romeo and Juliet," Act i, sc. 4. § "Midsummer-Night's Dream," Act i, sc. 1.
‖ "Mr. J. Allies's "On the Ignis Fatuus."

hammer, and by "false fires," drew him on to the worst ore in the mine. Countless are the stories told in Devonshire of these Pixy illusions; and a popular means of counteracting them was to turn one's coat inside out—a remedy which appears to have been in use in other parts of England, being mentioned by Bishop Corbet in his "Iter Boreale":

> ". . . William found
> A mean for our deliverance. Turne your cloakes,
> Quoth hee, for Puck is busy in these oakes;
> If ever wee at Bosworth Hill be found,
> Then turne your cloakes, for this is fairy ground."

In Cornwall, a strong belief prevails about the mischievous pranks of the piskies, and they are the subject of numerous superstitions. They are said to control the mist, and to have the power, when so disposed, of casting a thick veil over the traveler as he returns home after sunset. Hence the peasant may occasionally be heard uttering the following petition with a certain degree of faith:

> "Jack o' the Lantern, Joan the wad,
> Who tickled the maid and made her mad,
> Light me home, the weather's bad."

By the Dorsetshire folk, this mysterious fairy is called a Pexy and Colpexy; and in Hampshire the Colt-pixy was the supposed sprite who led horses into bogs and other outlandish places. Once more, as a further proof of the connection of the elfin or fairy-face with the *ignis fatuus*, it may be noted that "Mab-led," pronounced Mob-led, signified led astray by a Will-o'-the-Wisp. Why, however, the fairy Queen Mab should be thus introduced originated, no doubt, in her fondness for playing jokes, as alluded to by Shakespeare in the passage already quoted above from "A Midsummer-Night's Dream."

According to Sir Walter Scott, the Will-o'-the-Wisp is a strolling demon or specter, bent upon doing mischief, who once upon a time gained admittance into a monastery as a scullion and played the monks all kinds of pranks. The followers of Marmion attributed the mysterious disasters that befell them at Gifford Castle to the guidance of the assumed ecclesiastic—"The Cursed Palmer"—and expressed the belief that it had been better for them had they been lantern-led by Friar Rush:

> "What else but evil could betide,
> With that cursed Palmer for our guide?
> Better we had through mire and bush
> Been lantern-led by Friar Rush."

The wandering demon, it seems, was known in many parts of Scotland by the familiar name of "Spunkie," whose freaks and mischievous character form the subject-matter of numerous lengthened tales. Mr. Guthrie, in his "Scenes and Legends of the Vale of

Strathmore" (1875, page 100), tells us how "many a poor benighted wight hath this uncannie warlock driven to his wits'-end by his uncouth gambols and deceptive light, and many a bold and valiant knight hath he laid *hors de combat* on the marshy plain." Milton in his "Paradise Lost" (book ix, page 634), while explaining the philosophy of this superstitious appearance, alludes to the notion which associates it with an evil spirit in the well-known lines:

> ". . . A wandering fire,
> Compact of unctuous vapor, which the night
> Condenses, and the cold environs round,
> Kindled through agitation to a flame,
> Which oft, they say, some evil spirit attends,
> Hovering and blazing with delusive light,
> Misleads th' amazed night-wand'rer from his way
> To bogs and mires, and oft through pond or pool,
> There swallowed up and lost from succor far."

In Normandy, the peasant believes that the Will-o'-the-Wisp is a cruel and malicious spirit whom it is highly dangerous to encounter. Mademoiselle Bosquet, in her "Normandie Romanesque et Merveilleuse," says that it follows and persecutes any unfortunate person who runs away from it; his only chance of escape, when sore-pressed, being to throw himself on his face and to invoke the Divine assistance. Hence the Feux Follet, as it is called, is a source of terror, and its weird appearance is much dreaded by old and young; many stories being told of the injury done to unwary travelers by its wicked knavery.

Again, a Danish tradition affirms that Jack-o'-lanterns are the spirits of unrighteous men, who by a false glimmer seek to mislead the wayfarer and to decoy him into bogs and moors. The best safeguard against them, when they appear, is to turn one's cap inside out. One should never point at them, as they will come if pointed at. It is also said that, if any one calls them, they will come and light the person who called.* A popular belief in Sweden says that "Jack-with-the-Lantern" was formerly a mover of landmarks, and for his unjust acts is doomed to wander backward and forward with a light in his hand, as if he were in search of something. Thus he who in his lifetime has been guilty of such a crime is believed to have no peace or rest in his grave after death, but to rise every midnight, and, with a lantern in his hand, to proceed to the spot where in days gone by the landmark had stood which he had fraudulently removed. On reaching the place, however, he is seized, says Mr. Thorpe, with the same desire which instigated him in his lifetime when he went forth to remove his neighbor's landmark, and he says as he goes, in a harsh, hoarse voice: "It is right! it is right! it is right!" But, on his returning, qualms of conscience and anguish seize him, and he then exclaims:

* Thorpe's "North-German Mythology," 1851, ii, 211.

"It is wrong! it is wrong! it is wrong!" There is also a Danish tradition which informs us that near Skovby, on the Isle of Falster, there are many Jack-o'-Lanterns. They are believed to be the souls of land-measurers, who, having in their lifetime perpetrated injustice in their measurements, are doomed to run up Skovby bakke at midnight, which they measure with red-hot irons, exclaiming, "Here is the clear and right boundary! from here to there." By another curious notion the Will-o'-the-Wisps are represented to be the souls of unbaptized children. On one occasion,* a Dutch parson, happening to go home to his village late one evening, fell in with no less than three of these fiery phenomena. Remembering them to be the souls of unbaptized children, he solemnly stretched out his hand and pronounced the words of baptism over them. Much, however, to his consternation and surprise, in the twinkling of an eye a thousand or more of these apparitions suddenly made their appearance—no doubt all earnestly wanting to be baptized. The good man, runs the story, was so terribly frightened, that, forgetting all his kind intentions, he took to his heels and ran home as fast as his legs could take him. In Lusatia, where the same superstition prevails, these fires are supposed to be quite harmless, and the souls of the unbaptized children to be relieved from their destined wanderings so soon as any pious hand throws a handful of consecrated ground after them.† A Brittany piece of folk-lore is that the "Porte-brandon" appears in the form of a child bearing a torch, which he turns round like a burning wheel—occasionally setting fire to the villages which from some inexplicable cause are suddenly wrapped in flames. According to a Netherlandish tradition,‡ because the souls of these wretched children can not enter heaven, they, under the form of "Jack-o'-Lanterns," take their abode in forests, and in dark and desert places, where they mourn over their bitter lot. Whenever they are fortunate enough to see any one, they run up and hasten before him, in order to show the way to some water, that they may get baptized. Should no one take compassion on them, it is said that they must for ever remain without the gates of paradise.

Among other legends connected with this subject, we may mention one current on the Continent, thus recorded by Carl Engel: § On the ridge of the high Rhön, near Bischofsheim, there are two morasses —known as the red and black morass—where two villages are reported to have stood which sunk into the earth on account of the dissolute life of the inhabitants.‖ On these two morasses there appear at night maidens in the shape of dazzling apparitions of light. They float and flutter over the light of their former home, but are now less frequently seen than in the olden time. A good many years ago, two or three of

* Engel's "Musical Myths and Facts," 1876, i, 407.

† Thoms's "Notelets on Shakespeare," 1865, 63.

‡ Thorpe's "North-German Mythology," iii, 220. § "Musical Myths and Facts," i, 208.

‖ Cf. similar tale in Hunt's "Popular Romances of the West of England."

these fiery maidens came occasionally to the village of Wüstersachsen and mingled with the dancers at wakes. They sang with inexpressible sweetness; but they never remained beyond midnight. When their allowed time had elapsed there always came flying a white dove, which they followed. Then they went to the mountain singing, and soon vanished out of the sight of the people who followed, watching them with curiosity. A Normandy tradition says that the *ignis fatuus* is the spirit of some unhappy woman,* who, as a punishment, is destined to run *la fourolle* to expiate her intrigues with a minister of the church; and on this account it is designated La Fourolle. A somewhat similar belief once prevailed in this country, for we are told† that the lights which are usually seen in churchyards and moorish places were represented by the popish clergy to be "souls come out of purgatory all in flame, to move the people to pray for their entire deliverance; by which they gulled them of much money to say mass for them, every one thinking it might be the soul of his or her deceased relations." This superstition is alluded to in the "Comical Pilgrim's Pilgrimage into Ireland" (1723, page 92): "An *ignis fatuus* the silly people deem to be a soul broken out of purgatory." It is also said that the Will-o'-the-Wisp is the soul of a priest‡ who has been condemned to expiate his vows of perpetual chastity by wandering about; and Mr. Thoms says it is very probable that it is to some similar belief existing in this country at the time when he wrote that Milton alludes in "L'Allegro," when he says:

> "She was pinched and pulled, she said,
> And he by Friar's lanthorn led."

Once more, in Altmark, Will-o'-the-Wisps are supposed to be souls of lunatics unable to rest in their graves, and are known as "Light-men." Although they may sometimes mislead, they often guide rightly, especially if a small coin be thrown them.

Such, then, are some of the principal legends and superstitions that have been connected with this strange phenomenon, the majority of which, while investing it with a supernatural origin, regard it as an object of terror; and, on this account, in our own and other countries, the peasantry still look upon it as a thing to be avoided. It was formerly thought to have something ominous in its nature, and to presage death and other misfortune. Thus, in Buckinghamshire,§ a species of this phenomenon, locally known as "the wat," was said to haunt prisons. Oftentimes before the arrival of the judges at the assizes it has, we are told, been known to make its appearance like a little flame, being considered fatal to every prisoner to whom it became visible. The

* See Mademoiselle Bosquet's "Normandie Romanesque et Merveilleuse."

† "A Wonderful History of all the Storms, etc., and Lights that lead People out of their Way in the Night," 1704, 75, quoted by Brand, "Pop. Antiq." iii, 390.

‡ Thoms's "Notelets on Shakespeare," 65. § Brand's "Pop. Antiq.," iii, 402.

same dread is attached to it in Sussex, and Mrs. Latham, in her "West Sussex Superstitions,"* tells us that in a village where she once resided the direction of its rapid, undulating movement was always carefully observed, from an anxiety to ascertain where it would disappear, as it was believed to be

> "The hateful messenger of heavy things,
> Of death and dolor telling"

to the inhabitants of the house nearest that spot. Considerable alarm was on one occasion created by a pale light being observed to move over the bed of a sick person, and, after flickering for some time in different parts of the room, to vanish through the window. It happened, however, that the mystery was soon afterward cleared up, for, as Mrs. Latham tells us, "when reading in her room after midnight, all at once something fell upon the open page and appeared to have ignited it. She soon perceived that the light proceeded from a luminous insect, which proved to be the male glowworm." In the same way the "corpse-candle" in Wales, also called the "fetch-light," or "dead-man's candle," is regarded as an ominous sign, and believed to be a forerunner of death. Sometimes it appears in the form of a plain tallow-candle in the hand of a ghost, and at other times it looks like a "stately flambeau, stalking along unsupported, burning with a ghastly blue flame."† It is considered dangerous to interfere with this fatal portent; and persons who have attempted to check its course are reported to have come severely to grief, many actually being struck down where they stood, as a punishment for their audacity. A Carmarthenshire tradition, recorded by Mr. Wirt Sikes, relates that one day, when the coach which runs between Llandilo and Carmarthen was passing by Golden Grove, three corpse-candles were observed on the surface of the water gliding down the stream which runs near the road. All the passengers saw them. A few days after, some men were about to cross the river near there, when one of them expressed his fear at venturing, as the river was flooded, and he remained behind. Thus the fatal number crossed the river—three—three corpse-candles having foretold their fate; and all were drowned. In conclusion, we would only add that Will-o'-the-Wisps have long ago happily disappeared from all marshes and lowlands as soon as drained and brought under cultivation—these "wild-fires," as they have been called, preferring some supposed haunted and desolate bog for their habitation. —*Gentleman's Magazine.*

* "Folk-Lore Record," i, 52. † Wirt Sikes, "British Goblins," 139.

CYNICISM OPPOSED TO PROGRESS.

By WILLIAM A. EDDY.

WHEN examining a question of possible corruption, or any form of crime, we find that nearly all men take a somewhat cynical view. So common is this that we may safely say that it applies to all who know the world. Yet a careful examination of facts, though giving us a vague idea of the real proportion of crime, must finally convince us that cynicism is simply the sentinel on guard to warn us against possible injury from exceptional qualities in others. It is clear that cynicism is due to the fact that there still remain traces of a mutually devouring condition of development. But this destructive position in thought ought not to remain extreme long after the advancing light has modified the conditions that partly justified it. In truth, there is in the nature of things a check to the cynical tendency in the fact that the realization of severity in thought is impeded by considerations that involve some deliberation. Thought and imagination easily lead to extreme conclusions never carried to a practical result, because it is often so much easier to think, and requires so much less time than to act. In other words, the thought may be cynical, but the every-day action is generally in accordance with the assumption that men are trustworthy.

As the advances are made directly through the influence of practical and talented men, and indirectly through the deepest thinkers, it follows that a low opinion of the general intelligence and morality tends to discourage all but men of genius, to decrease the number and extent of higher influences, and to retard material advancement. One of the striking characteristics of the age is the promptness with which money is invested and speculative enterprises are carried forward. The prevailing tendency is to assume the inevitable success of a project, and overlook the chances of failure. In fact, the liberality with which our country is supplied with improvements in steam transit, newspapers, ocean-cables, telephones, etc., denotes that the modern spirit is far from cynical. The transaction of business, except in a limited and inefficient way, would be impossible if the majority of men were swindlers.

It is with much satisfaction that we observe a general conspiracy in the drift of affairs whereby a negative way of viewing things fails to become general. Affirmative and cheerful people have positive force that dispels the shadows of needless anxiety with excess of light. The friends with whom we are the most unreserved, and who exert the most social power generally, are not severe in their judgments. The cheerful man is a center of attractive force, while the cynic at times dissipates important and beneficial influences. In truth, the

ideas of the cynic are like blasts of cold air, out of which people are glad to escape with the utmost promptness. Cynicism does not represent as much intelligence as the constructive tendency, because cynical ideas are allied to feeling and held without reference to any wide generalization of facts. Events take place or combine in a purely intellectual way, or in accordance with laws of necessity and causation. But in opposition to this principle we often find the vague expectation that events can be modified by emotional action, or feeling, or by theories not adapted to experience. The seeming obduracy of inanimate objects, when we try to disentangle their complications by means of anger, shows that emotional action may be quite absurd when applied to affairs of the intellect. A like suggestion of mania is observable in the cynicism which sees in human nature only different grades of rascality. It is a subjective conclusion deduced from exceptional instances.

In addition to the want of effect due to emotional conclusions reached regardless of objective causes, we find further source of error in the very common cynical belief that there is ultimate strength in deception. Bonaparte claimed that much of his success resulted from his ingenious lying, but his power really lay in his reasoning, his knowledge of human nature, his wonderful constructive force, and his grasp of details. These qualities are intellectual, powerful, positive. The success of his lying depended upon intellectual weakness or deficient knowledge in others, and not upon superior power exerted in spite of their relative intelligence. Strategy, like stimulants in sickness, may bridge over a chasm, but, when subjected to the test of time or innumerable repetitions, it is inevitably exposed by unexpected and incalculable events. In fact, deceptive action often has an air of absurdity, humorous as well as geometrical, as seen in Dickens's judge, who, at the Bardell trial, tried to conceal the fact that he had been aroused from sleep—when Buzfuz ceased speaking for a moment—by apparently writing with a dry pen, and then looking as if he thought most profoundly with his eyes shut.

Spinoza was right in his conclusion that destruction and violence are negative. The highest form of conceivable existence, the most real, must be in accordance with principles of reason and harmony. This implies the elimination of discord or destruction, which in its effects upon our consciousness is always negative—that is, tends toward indefiniteness and a vanishing-point. Consciousness is reduced almost to zero during intense pain, because there is simply one sensation, and no sustained or connected line of thought including many ideas.

Reasonable mental actions are usually present, but if we select negative mental actions—hate, fear, envy, anger—we are at once conscious of their exceptional nature as compared with the total amount of time consumed by more rational forms of thought. It is observ-

able that persons noted for manifestations of motiveless malice are often reputed to be incipiently insane.

All forms of envy are magnified by the instant prominence which they occupy in thought. In an orchestra of ten instruments the harmony of nine may be overpowered by one that persists in playing out of tune. The presence of envy and malice in one person may cause us to lose sight of its absence in ninety-nine. We may therefore conclude that cynicism, which is the perception of the dark side of everything, can never become a great destructive force, because it can not accumulate power. It must ever remain a standing threat, a stimulus to right thinking. The higher forms of power in men are positive and not passive. Superstition and the darkness of cynicism must be swept away by the evolution of intelligence.

SOME PREHISTORIC VESSELS.

A VERY remarkable archæological discovery has recently attracted the attention of the scientific world in Scandinavia, and has become a matter of popular concern in Norway, where every one is interested in the ancient and glorious national traditions. The baths of Sandefiord are situated in the southwestern part of the fiord of Christiania. The road from that place to the ancient city of Tansberg passes near the village of Gogstad, not far from which is a tumulus or funeral-mound, which has been long known in the local traditions under the name of Kangshaug, or the Mound of the King. This heap, which is nearly fifty metres, or more than one hundred and sixty feet, in diameter, rises in a gentle slope from the level of the plains and meadows which extend from the fiord to the foot of the mountains, and is covered with a verdant sod. According to the legend, a powerful king had chosen the spot as the place where he should finally rest, surrounded by his horses and his hunting-dogs; and his most precious treasures had been buried near his body. Superstition and the fear of avenging spirits had for centuries prevented every kind of examination of the tomb, but the investigating zeal of our age ventured to penetrate the mystery. Excavations were made, and brought forth the discovery of an entire viking's war-vessel, and the grave of the unknown chief by its side.

The sons of the peasant on whose land the tumulus was situated began to dig into it in January and February, 1880; they turned away a spring which they found in digging, and soon afterward met with building-timbers. Wisely, they suspended their labors to bring them to the attention of the society at Christiania for the preservation of ancient monuments. This society took charge of the subsequent

excavations, and sent Mr. Nicolaysen, a learned and skillful antiquary, to superintend them. They were continued under his direction during April and May, and finally brought the viking's vessel into view. The ship was twenty-two and a half metres (or about seventy-two feet) long, five metres (or seventeen feet) wide in the middle, would draw a metre and a half (or five feet) of water, and had twenty ribs or benches for rowers. It is considerably the largest vessel of antiquity that has yet been discovered.

The Danish Professor Engelhardt, in 1863, unearthed from the turf-pits of Nydam, in Schleswig, a vessel fourteen metres (or forty-five and a half feet) long; and another vessel was found in 1867, at Tune, thirteen metres (or forty-two feet) long. Neither of these vessels could be compared, however, as to its state of preservation or its dimensions, with the one found at Gogstad.

The tumulus is now nearly a mile from the sea, but the nature of the alluvial soil makes it evident that the waves formerly washed its base. The vessel had, it then appears, been drawn immediately out of the fiord, and placed upon a bed of fascines or hurdles and moss. The walls had then been covered with clay, the hold filled with earth and sand, and the whole covered over so as to form a tumulus. The prow of the vessel was turned toward the sea, for at that period it was believed that, when God should call the chief, he would come out of his grave and launch his ship all equipped upon the waves of the ocean.

Some interesting objects were found on the prow of the vessel, which at first escaped attention. A piece of a beam showed the hole in which the shaft of an anchor had been inserted, but only bits of iron were found. The remains of two or three small oaken canoes of very fine form were unearthed, and by their side were found a number of oars, some of which were intended for the canoes, and some for the vessel itself. They were eighteen or twenty feet long, and of a shape much like that of the oars which are used in England in regattas. The blocks were worked very thin, and some of them were ornamented with carvings. The floor of the ship was as well preserved as if it had been built yesterday, and was adorned with curved lines. Some pieces of wood seemed to have formed parts of drag-nets. Certain beams and planks are supposed to have formed partitions separating the benches of rowers from one another, leaving a passage in the middle. A neatly shaped hatchet, several inches long and of the form common to hatchets of the iron age, was found on a pile of oaken chips. Some beams had dragons' heads at their ends, rudely carved and painted in the same colors as the walls of the vessel—that is, in black and yellow. The colors are still bright enough to show that water has not greatly affected them. As olive and other vegetable oils were then unknown, we must suppose that the colors were prepared with some kind of fat, perhaps with whale-oil.

The excavations were continued till the whole length of the vessel was exposed. All along the outside of the walls, from the prow to the poop, extended a series of circular bucklers lapping one over another like the scales of a fish, of which nearly a hundred, partly

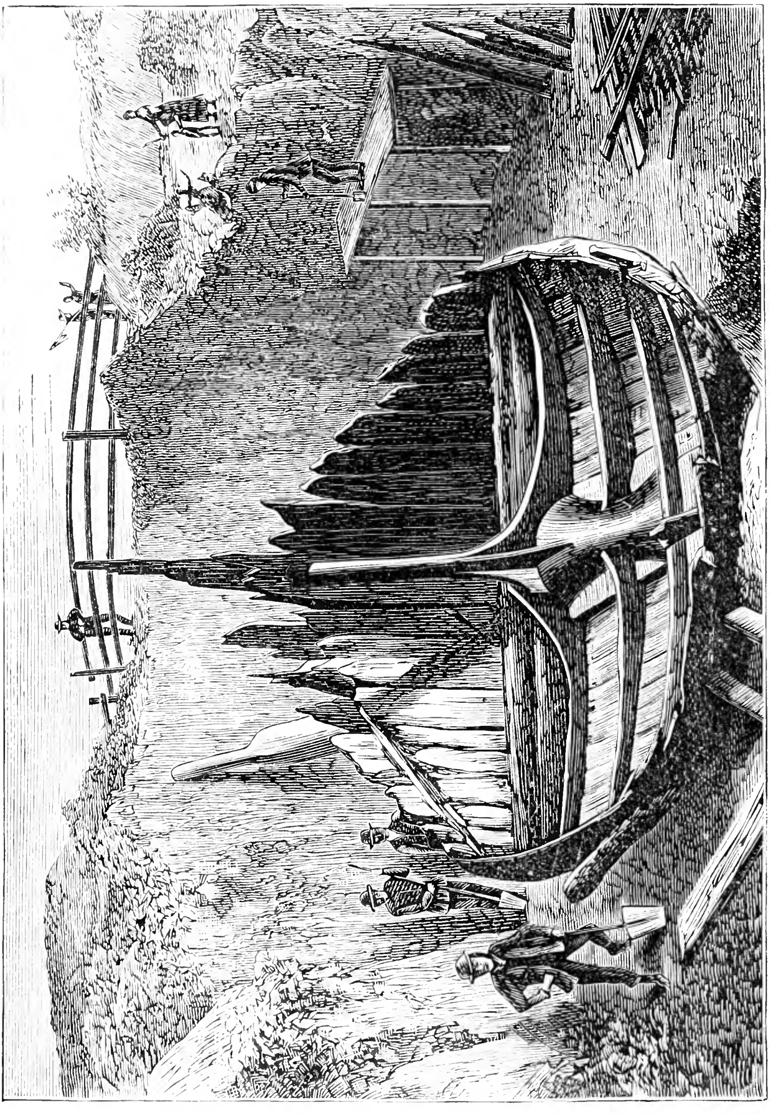


Fig. 1.—Ancient Scandinavian Vessel found in the Tumulus of Gogstad, Norway.

painted yellow and black, remain. In many places the wood of the bucklers has been destroyed, and only the central plate of iron is left. The famous tapestry of Bayeux shows quite plainly how the vessels of the vikings were furnished with rows of bucklers (Fig. 2), but it

has been supposed that they were the shields which the soldiers used in action, and which were hung there for the sake of convenience. It is now evident that they had no purpose but ornament, as they were of wood, not much thicker than pasteboard, and could not resist a sword-thrust that was given with any force.

A large block of oak, solidly fixed in the bottom at the middle of the vessel, had a square hole for the mast; and some circumstances indicated that the mast could be laid down. A few pieces of rope, and some rags of a woolen stuff, probably the sail, were also found.

The funeral-chamber was built on one side of the tumulus, with strong planks and beams set obliquely one against another, the whole occupying a space of two or three square metres. This was opened, with the expectation of finding arms or precious objects, but the explorers were disappointed. The tomb had probably been violated at some previous epoch. A few threads of a kind of brocade, a few parts of bridles and saddles, some articles in bronze, silver, and lead, and metallic buttons, on one of which was artistically represented a knight letting down his lance, were all that could be found here. The bones of a horse and of two or three hunting-dogs were discovered in the sides of the chamber.

A large copper vessel, supposed to be the kettle of the ship, was found in the forward part of the boat. It had been hammered out of a single sheet of copper, and afforded satisfactory evidence of the industrial skill of those remote times. Another vessel, of iron, with ears and a bail, was found, with some wooden bowls near it. It was at first intended to remove the whole of the ship to the Museum of Christiania, and Mr. Treshan, a large proprietor of the neighborhood,

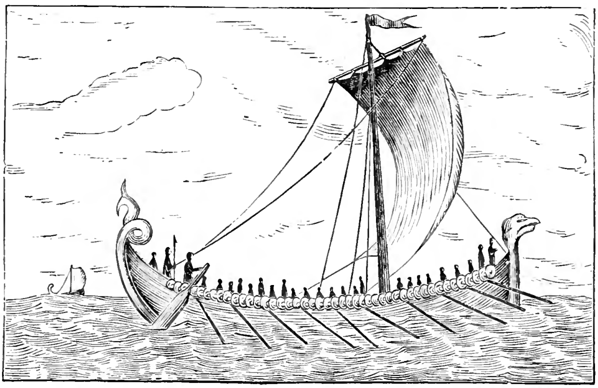


Fig. 2.—Attempted Restoration of an Ancient Scandinavian Vessel.

offered to pay the expense of the removal. The persons having the matter in charge, however, decided, after a careful examination and consideration of the subject by an expert, that it would be impracti-

cable to carry the vessel away, and that it would be better to cover it from the weather and leave it where it was found. Only the smaller objects were taken to Christiania.

Antiquaries have agreed in ascribing the epoch of the erection of the tumulus to the most ancient iron age, or to the ninth or tenth century of our era—most probably to the age of Harold the Fair-haired, founder of the Norwegian state.

Dr. V. Gross, of Neuveville, Switzerland, has furnished a description of an ancient canoe which was found in April, 1880, buried in the ground near the shores of the Lake of Bienne, and which has been placed in the museum at Neuveville. It is of oak, and differs somewhat in shape from similar canoes that have been found heretofore. The stern has the square form of modern boats, and the prow

FIG. 3.—LACUSTRINE CANOE FOUND IN THE LAKE OF BIENNE.

is adorned with a spur-shaped prolongation (Fig. 3). The boat is 9·55 metres (or a little more than thirty feet) long, from two and a half to three feet broad, and about nineteen inches deep. Rounded notches at intervals along the sides seem to have been intended as rests for oars. A piece of about five feet by nine inches appears to have been broken or taken out of one of the sides near the stern, the place of which may have been supplied by a plank. In order to preserve the form of the vessel against warping and shrinkage, it was soaked in boiled linseed-oil to which colophene was afterward added. The application, after a sufficient number of repetitions, was attended by such satisfactory results that Dr. Gross has no hesitation in recommending it for all objects that are too bulky to be put in glycerine.—*La Nature.*

THE HORACE MANN SCHOOL FOR THE DEAF.

By MARY GRAY MORRISON.

THERE is a schoolhouse in a convenient little by-street in Boston, which is visited weekly by scholars and scientists, specialists of renown and commonplace fathers and mothers, philanthropists and seekers after the curious, and from its doors not one turns away without being surprised and touched.

The Horace Mann School for the Deaf, in Warrenton Street, is one of the latest developments of that great humanitarian movement which rose like a miracle in the last half of the eighteenth century, one of the few sunbeams which have come to us from those dark and

faithless days. It was opened under the name of "Boston School for Deaf Mutes," in November, 1869, with twenty-five pupils. Two removals have been made since that time, but the eighty members comprising the school are now pleasantly located in the present building, which contains eight class-rooms, a reception-room, and play-room.

The name of the school was changed in 1877, because the pupils who were learning to speak objected to being called "mutes"; a prejudice which the city very wisely considered. As early as 1843 Mr. Horace Mann, then Secretary of the Massachusetts Board of Education, described in one of his reports the German method of teaching articulation, and urged its adoption here. It was a suggestion which, as Dr. Howe said, "took twenty years to bear fruit," but it was gracefully remembered in changing the name of the school which now teaches that method with marked success. It is both a city and a State institution, and in that way has some advantages over an ordinary public school; a longer recess, for example, and but one session instead of two.

And in this cheerful place, in an atmosphere of encouragement and affection, the children gladly stay during five hours of the day; while the teachers, who are enthusiasts in their work, patiently try to fit them to take their places more equally in the struggle of life.

The work is very slow. When we remember that most of these pupils have never heard a sound, and do not know what it is, that they have no communication with the world except by pantomime, and then remember that the end aimed at is to make them speak the English language, so that any one can understand them, and that they must learn to read from the movements of his lips whatever a hearing person chooses to say to them, the tremendous toil will be faintly realized.

From the time in the last century when the first government institutions for the deaf and dumb were founded simultaneously in Germany and France, the methods of instruction have been different in those usually antagonistic countries.

The Abbé de l'Epée contented himself with the sign-language, and his idea is still the ruling one in the French school, for its defenders hold that the thinking and reasoning qualities are better brought out with a language which, when once learned with comparative ease, allows the mind free play, than with a system where the whole powers of the pupil must be given for years to expression.

On the other hand, Heinicke, of Eppendorf, believed that the dumb could be taught to speak, and this has been the principle of the German school from the beginning. There is no doubt but the latter method would place its pupils upon a better footing with their fellow-men, from whom the sign-language must separate them to a great extent, but to become general it is necessary that in a majority of cases it should be a pronounced success. In the instances which have come

under the writer's notice, it has not appeared that the ideas of the pupils are dwarfed by the process; rather does it seem as if, with the first spoken word, a spell were broken and they were free.

Professor Bell's system of visible speech has been used in the Horace Mann School from the beginning; but an attempt is being made, with apparent success, to do away with even this artificial method, and, keeping it as an occasional aid, to teach the English language directly.

The teacher in beginning her work writes a word on the blackboard, pointing to the object in the room for which it stands; and the child is made to understand by constant repetition that that written word and that object are always meant for each other. A number of such nouns are written and rehearsed until the pupil will point readily to the object when the written characters corresponding to it are shown him, or will write the word when the object is placed before him. These children often learn to point to the nouns wholly by the looks of the written words before the little fingers can use the pencil, though they naturally write quickly and well—earlier than children who hear.

Perhaps the child's first vocal attempt is to close his lips, and make the humming sound produced by an effort to speak the letter *m*; and he does so by feeling the curious vibrating sensation in his teacher's lips and chin, and trying to imitate it. In nine cases out of ten he does this the second time he tries, no one knows why. The instant he succeeds, the letter *m* is written triumphantly for him on the blackboard, and he feels that his oral education has begun. After this, very probably the long sound of *e* is attempted, the mouth open, the tip of the tongue pressed against the lower teeth, and the vibrations again felt. The pupils are early shown, however, that the mass of vibratory tone must come from the base of the chest by the action of the diaphragm, for otherwise the register of sound is apt to be unpleasantly placed either in the throat or head.

The vowels are usually taught first, and each of these elements sometimes requires weeks of patient work to get perfectly. Having succeeded, the consonants are added, *fe*, *re*, *be*, *sa*, *ta*, *no*, *so*; and words naturally follow.

There are always two classes of children in schools of this kind, the congenital mutes who have never heard, and a large number who were not born deaf but became so in different stages of their age and development, either by disease or accident. Scarlet fever alone is computed to cause one third of the deafness in America. These two classes are separated as far as possible, for the semi-mutes usually retain a few words or sentences upon which to build, while the congenitals must begin far behind them, everything being artificial.

As all the teaching must be objective, the class-rooms present an animated appearance, gay with pictures upon the walls and colored crayon drawings upon the blackboards.

When the child enters the school he is usually provided with a language of natural pantomime which is practical and very entertaining. The sign of "mother" is putting the hand to the back of the head, as if a coil of hair were there, while for "father" the hand is drawn over the face in the manner in which he wears his beard. A cow is represented with the thumbs at the ears and the fingers extended; a donkey the same, with the fingers together and hands slowly opening and closing.

Some of the gestures are very pretty. A child tells his teacher that his father was asleep when he came to school, by making the sign for father and inclining his head to one side with closed eyes upon his open palm, and shows his anticipation of some pleasure he is to have, by making the gesture for to-morrow, over and over again; with one forefinger he closes his eye, and, lifting it quickly, makes it a figure *one* (opening his eyes, of course, at the same time), meaning that he will *sleep once* before the time comes.

It is strange that all children, coming from whatever place or condition, have these natural gestures alike when they enter the school. The quick motions of the little fingers, as they tell a long story in this way, remind one of humming-birds.

The children are as different from one another as hearing childreu are. Some are so pretty that artists might covet them, little ones who have not yet learned to speak, but who look up at you silently, statues in which the soul is to awake; others, dwarfed and distorted in figure, have a look of dull despair, too old for childhood. The heart is sad and tender for them all.

Every gesture is vigilantly suppressed as soon as the written or spoken word can be used in its place, but in the youngest class these signs are naturally most used. An animated group the eleven pupils make, several of them mere babies of four and five years. They ask very personal questions about the visitor, which the teacher readily interprets if she sees fit. There are some inquiries concerning the age of the stranger, for instance, or innocent comments on the size of his feet, or the shape of his hat, which she may think best to ignore. In this class is Charley, whose teacher spelled his name in the more common way until he intimated to her that he objected to having a *lie* on the end of his name! Constant association with one of the girls in the class, who had a prejudice against the unvarnished truth, had early familiarized the eleven with the word. This girl has a lively imagination and a strong vein of romance, which cause her, perhaps, to seem unreliable to slower intellects. She never, for example, sees a companion with a new necklace or dress, but she carelessly signs to her that she herself possesses such articles by the barrel and bale; while her own home, which she describes to open-eyed listeners, as built of gold with a diamond door and silver steps, has long been known by reputation throughout the school. This pupil, in her one interview with the

writer, asked if she had a hat with a long white feather, if she had a gold bracelet, if she played on the piano, and had a door-plate on her door; and the latter, as she sorrowfully shook her head, felt the degradation involved in the admission.

Once in a while one of these little ones is stubborn, and, refusing to be taught, closes his eyes. This, of course, throws the teacher upon his mercy ; there is nothing more effective he can do.

In cases of great rage, one child indicates, by practical illustration, that its opponent has a father who drinks and a mother who is fat. Insult among them can go no further than this, and the teacher is summoned by the wail of the accused.

Their misfortune keeps them, in a large measure, from understanding the distinctions of rich and poor, differences it is so sad to see, made sometimes by children as soon as they can stand alone. The little dainty daughter of a house whose one great cross is this child's deprivation, admires with loving touch the golden hair of her school-friend whose shoes are worn at the toes, and whose dress tells its own story of the mother's poverty and overwork.

We must not turn from this interesting youngest class, without mentioning the pretty, sensitive little girl of four years, who described a ride which a gentleman had given her ; standing as she did upon a chair with her audience around her, she made quick gestures with her fingers, her eyes turned brightly upon each face before her, but, as she proceeded, her remembrances went beyond her power in signs, and with intent, serious face she traced, with her forefinger in the air, sketches of the rest she had seen. We did not understand what she meant to tell us, but almost a feeling of awe fell upon us as we looked on at this dumb intelligence which was being led by the mind that is greater than ours.

Nor should the boy a little older be forgotten, a pale, sickly child, who goes regularly to church on Sundays, and seems to enjoy it. One day, when a copy of the "Madonna and Child" was shown, and one of the other children was puzzled by the subject, this boy told his companion the story of the Saviour from his babyhood to his cross in these natural signs, not dreaming that his teacher had seen it all.

For a long time after children enter the school they think their fathers and mothers and teachers are all like themselves, and have learned to speak in the same way as they are being taught. This delusion lasts for some time, but generally fades out gradually. Once in a while, however, it comes as a shock. One of the younger pupils who still had this idea, as she sat watching her teacher and a visitor, noticed apparently that the teacher sometimes spoke to the new-comer without looking at her, and that she answered in the same way. It struck her for the first time, evidently, that these were not dependent upon the movements of the lips. As the visitor departed, the child went up to her teacher, and, pointing after her, laid her finger on her

teacher's lips, and, looking up at her, shook her head. "She did not watch my lips?" asked the teacher. "No, she hears." And she pointed to her ear. The child, then pointing to her teacher's ear, looked up in question. "Yes," answered the latter, "I hear too." She stood a moment trying to understand it; then she laid her finger on her own ear, pointed to herself and slowly shook her head. The knowledge of her difference from the common order of things had come to her.

As one passes from the youngest to the oldest class, the progress is very marked. In some of the rooms the pupils only say separate words, in others a few sentences; but in the last a surprise awaits every one. There sits a class of nine pupils from about thirteen to sixteen years old, who, at the low-toned request of their teacher, rise, come forward to nearer seats, and recite the answers clearly and correctly to the questions of an ordinary geography lesson. Five or six of them spoke with especial ease, and the teacher assured the visitor that, not only could a prolonged conversation be kept up with them upon any subject, but that, in fact, the class had probably understood all the visitor had been saying since she came in. Their faces lighted up when one of them hesitated a moment for the answer, and each one showed an anxiety to be questioned; they whispered to one another, and were reproved for it just like the restless little creatures imprisoned for five hours daily in any other school in the city. One girl, in particular, spoke with such a pleasant inflection and so much animation, that the visitor said, "She must be a semi-mute, surely?" "No," the teacher answered; "all of my pupils were born deaf." Of two who seemed a little backward, she said: "They are not strong children, and their articulation is not so good as the others; but it is a great advantage to them to be able to understand what is said to them, even if they never speak very well." She further stated that all the usual studies of the upper grammar-school classes were pursued by her own. It seems to all who see it a marvelous thing; but the ignorance still prevailing in regard to the system and its results is incredible. The teachers say they are asked the strangest questions every day: Why they do not teach the children to sing; whether they use raised letters; whether their work is not easy, as it must certainly require but little education to teach such benighted minds. But everything was outdone by the prominent member of a board of education who, after expressing his amazement as he passed from grade to grade of the school, asked, "How long is it before they begin to hear?" A wonderful system, indeed, he must have thought it; and he could not plead the possession of a depth of general ignorance such as a chance glimpse discovered in the mind of that woman who came in to visit the school, and, after taking a large part of the teacher's time to explain the method, looked over the young faces before her once again, and asked, "Now, air thim *sinsible?*"

One of the most beautiful things about the school is the affection

existing between the teachers and pupils, and among the children themselves. Many of the little ones are poor, and are clothed mainly by the teachers and friends of the school, and when one of them appears in a new dress all of her fellow-pupils rejoice with her.

After they leave the school, which many do to engage in some employment, they are proud to keep up their proficiency, and encouraging and curious things are heard of them. One is a teacher in a Sunday-school; one is vigorously pursuing her studies in a branch of the Society for Home Culture; another practices her piano-lesson an hour a day; one boy is a promising student of wood-engraving; and the other day a lady recognized in the young girls who were talking happily together beside her in a horse-car two past members of the Horace Mann School.

All this is fair fruit from the labors of that Eppendorf scholar who sowed his seed a hundred years ago, and it would gladden the hearts of the many men who have longed to see this result from the darkness of the middle ages until now. Separate instances have been known in all time, where devoted men and women have given a lifetime to this work, and counted it well spent. We do not know the impulse which led the Spanish monk, Pedro de Ponce, in Leon, to the wonderful toil and patience which must have been required before his four deaf-mutes talked with men in the sixteenth century, but we hardly doubt that it began in the affliction of some one dear to him; for, almost always, until the feeling of duty which we owe to these sufferers became so general as it is now, in the isolated cases that stand out from the pages of all history we read between the lines the record of a devoted love.

Even if some of the pupils of the Horace Man School, and the similar institution in Northampton, should never be able to hold protracted conversations upon all subjects, there are many sentences with which they will always be able to gladden the hearts of their parents and friends.

As some one has wisely said, it would be well worth sustaining the system if the child only learned to say "Father, mother, I love you." For the parents feel the happiness of hearing one word pronounced by the lips of their children; and the father who said to the teacher that he would give his ten-thousand-dollar farm if that little girl of his could speak to him, echoed the greatest wish of many other hearts than his.

But the children learn more lessons than are mentioned in the school reports—neatness, obedience, gentleness, kindness; and thus are the teachers in many ways setting these captives free.

COLOR-BLINDNESS.

By S. R. KOEHLER.

WE have become so accustomed to color in all the objects about us, that we may almost be said to take no notice of it. Day after day we look upon the wealth of color in the landscape by which we are surrounded, without hardly ever giving it a thought. Some of us never awake to the perception of the beauty of color in nature; to others the knowledge of this beauty is only opened through the medium of art. A person who has taken little interest in paintings, but who, by some circumstance or other, is at last led to a more attentive study, especially of landscape-painting, will frequently be surprised by the enhanced interest which Nature ever after awakens in him. He finds charms where he never sought them before, and sees beauties to which he had been totally blind. The mystery of color has been unfolded to him, or rather he has been made conscious of his own faculty of perceiving color—a faculty which had, indeed, been always in him, but which had lain dormant.

Even to those, however, who are fully alive to the charm of color, the latter is so much a matter of fact that they take its presence for granted, and accept as a foregone conclusion that it can never be otherwise. The question, How would the world look without color? has never troubled their minds, and, if it were really proposed to them, they would probably meet it with the reply that there was no need of speculating about impossibilities. Yet that which appears to be so impossible is really possible; for there are not only people in existence who do not see, never saw, and never will see color, but we may even create something approximating such a colorless world for ourselves, at least as far as the artificial sphere is concerned in which we move within our houses.

Before me, as I write this, hangs a Chinese painting, executed in all the brilliancy of Oriental coloring—rich vermilion, fine blues of various shades, greens, and other full colors. I light an alcohol-lamp, into the wick of which I have rubbed some common table-salt. I turn down the gas, and, as I now look at the Chinese painting in the dim light of my magic lamp, all its color has disappeared. I *know* the vermilion, the blues, and the greens are all there, but I can not see them. And yet I see the picture itself quite plainly, with its outlines and its delicate gradations; but it is all black and gray, with only a faint trace of yellow here and there, where a yellow pigment has been employed by the artist. Beside me on my writing-table lies a sample-chart of water-colors; but, however intently I look at it, I can see nothing but spots that seem to have been produced by India-ink in various gradations. I travel round my room, and all the objects ap-

pear to me of the same somber hue. The embroidered cushion on the lounge, the carpet on the floor, even the flowers in the vase—they are all black and white, or at the best yellow. The little world that surrounds me is colorless.

Imagine, then, for a moment the whole world deprived of color. How would it look? An enamored poet singing to his adored in the world as we at present know it might, perhaps, prelude his ditty thus:

> "Thou rosy maiden with rich, ruby lips,
> And hair as golden as the sun's bright rays!"

Translated into the language of a poet of the colorless world, this strain would run about as follows:

> "Thou grayish maiden with dark, jetty lips,
> And hair as white as freshly fallen snow!"

We, who are accustomed to the charm of color, turn away shudderingly from such a world, in which we would all look like the figures in a steel-engraving, printed in the blackest of ink on the whitest of paper.

And yet, as I have said before, there are people who live in such a world continually, and must continue to live in it to their days' end. Fortunately, however, the instances of people who are totally *color-blind*—that is to say, who are absolutely incapable of experiencing the sensation of color—are extremely rare; and, to the few people so afflicted, the deprivation is not so great as it would seem to be to us, since, having never known the poetry of color, they do not feel the want of it.

But, although there are only very few people indeed who are *totally* color-blind, there are, on the other hand, a very large number of persons, especially among the male sex, who are at least partially so; and it is even more difficult to picture to ourselves the world as it is presented to their eyes than to imagine a world entirely destitute of color. Defective color-vision of this kind is most frequently manifested in the inability to see the difference between red and green. A person thus afflicted can detect no difference between the ripe cherry on the tree and the leaves by which it is surrounded, or between the strawberry and the stems and leaves of the plant on which it grows. Even the bright red of some flowers may only present itself to such persons as a lighter shade of the color of the leaves, while yellow and blue are perceived by them quite as distinctly as by persons of normal vision. To them, therefore, the world must bear a resemblance in color to some of the old pottery which is decorated in blue, yellow, and black, on a whitish ground. There are other varieties of defective color-vision, all of which may be generally described as an inability to perceive certain colors, while the perception of certain other colors is normal. The simplest method of picturing to ourselves the

world as it is seen by some color-blind persons is to hold up before the eyes a glass vessel with flat, parallel sides, filled with a solution of sulphate of copper. We shall then be pretty much in the same condition as a *red-blind* person.

The inconveniences which color-blind people must frequently be exposed to are manifest. Numerous stories are told of the most ludicrous mistakes made, especially by red-blind persons: of a tailor, for instance, who mended a black coat with a piece of red cloth; of a hunter who bought red cloth to have made what he supposed would be a green hunting-jacket. The story of the tailor shows how this malady, or, rather, constitutional defect, may do injury to men in their professional capacity. But the consequences that may possibly arise from it are of a far more serious nature when the safety of a large number of human beings is dependent on the color-vision of a single individual. This is the case with railroad operatives, who must be able without fail to tell one signal from another; and, as of late years the conviction has gained ground that color-blindness is far more common than it was formerly supposed to be, the railroad companies are warned more emphatically from year to year by scientific men to see to the eyes of their employees. Some of the European Governments are beginning to turn their attention to this important matter (all the more important because railroad-signals are usually red and green, and red-blindness is the most common form of the failing), and the Swedish Government has lately directed the physicians attached to its state roads to examine all the operatives on these roads, with a view to the detection of the presence of color-blindness. The first fruit of this order is a report by Professor Holmgren, who recently examined the employees of the Upsala-Gefle road, showing that, out of two hundred and sixty-six individuals, eighteen were afflicted with the malady to a degree sufficiently high to incapacitate them entirely for service on the road. The prevalence of the disease varies in different countries, the highest percentage being found in England, where, according to a statement made by Professor von Bezold, in his "Theory of Color," republished in this country in an English translation, one out of every eighteen persons is said to be afflicted with it. Among men, as before remarked, the disease is more common than among women.

The cause of total or partial color-blindness may easily be understood if we accept the hypothesis first brought forward by the English physicist Young, and now subscribed to by the leading scientific observers of all countries. According to Young, all the phenomena of color-vision are due to the (hypothetical) presence of three different kinds of nerve-fibers in the retina—that is to say, in that part of the eye on which the reflected images of the objects of the outer world are projected as upon a screen, and through the agency of which the sensations produced by the impressions so received are transmitted to

the brain. One of these sets of nerve-fibers is supposed to respond most readily to red, the other to green, the third to violet, or to a blue which verges closely upon violet. When all these nerve-fibers are absolutely at rest, we see nothing. Improperly speaking, we might say that we then experience the sensation of black, for absolute black really produces no sensation, but is rather the result of the absence of all sensation. On the contrary, when all the nerve-fibers are excited simultaneously and to an equal degree, we experience the sensation of white, provided that the amount of excitation is tolerably great. If the excitation is only feeble, we see what we call gray—gray being simply white of a low degree of luminosity. All other color-sensations are produced by the excitation of groups of nerves variously combined. Thus, whenever the fibers which respond to red and those which respond to green are excited simultaneously, we experience the sensation of yellow; when the two groups which respond respectively to green and to violet are simultaneously excited, we experience the sensation of blue, and so on through the whole scale of colors. Again, when all the nerve-fibers are excited at once, but to an unequal degree, we perceive the result of the mixture of one predominating color with the others. If we suppose the nerves responding to red to be the most violently excited, we shall experience the sensation of red mixed with white, or, in other words, of light red.

It will readily be seen that this hypothesis explains the curious condition of color-blind persons very satisfactorily. In the case of total color-blindness, we need only to assume that the nerve-fibers are in an abnormal condition, so that each set, instead of responding to only one sensation, responds equally to all. The result must necessarily be a total absence of color in the impressions received through the eye. In the case of a red-blind person, the nerves which ought to respond to red may either be paralyzed or they may be wanting altogether, and all other defects in color-vision may be explained upon the same principle.

To a limited extent the inability to tell the difference between certain colors, which is due to partial color-blindness, may be overcome by the use of variously colored glasses; but, after all, no artificial palliative will compensate for the want of a naturally perfect eye.

THE EUCALYPTUS IN THE ROMAN CAMPAGNA.

By H. N. DRAPER, F. C. S.

SO much has already been written by way of contribution to our knowledge of the different species of the eucalyptus-tree, that, interesting as the subject is, it may well be considered to have received already a fair share of attention. There is one aspect of it,

however, which can not perhaps be dwelt upon too much, and that is the value of this genus of plants as drainers of the soil and purifiers of the atmosphere. This is probably the true reason why so many attempts, more or less successful, have been made to acclimatize the eucalyptus in Southern Europe and even in Great Britain. No doubt, experiments have been stimulated by other causes. The foliage of these trees is, for example, unlike that of any other in our islands. It is pendulous, quivering, and evergreen; and the peculiar whitish appearance of one side of the leaves—due to a fatty or resinous secretion—is very characteristic. Till the tree is from three to five years old, the leaves grow horizontally; but afterward they generally assume a pendent position. Instead of having one of their surfaces toward the sky, and the other toward the earth, they are often placed with their edges in these directions, so that each side is equally exposed to the light. This arrangement may have something to do with the extraordinary quantity of moisture these trees exhale into the atmosphere.

The eucalyptus belongs to the natural order *Myrtaceæ*, and is indigenous to the temperate parts of Australia (where it goes by the name of stringy-bark, or gum-tree) and Tasmania—that is, where the mean temperature does not exceed a range of from 52° to 72° Fahr. The foliage is leathery, and almost always characterized by a certain *metallic* aspect. The leaves are as a rule narrow, and have either a very short and twisted petiole or foot-stalk, or none at all. In Australia they commonly attain a height of two hundred feet, and instances are given in which a height of three hundred and fifty feet has been attained. The flowers are usually pinkish or white, and in the latter case superficially resemble those of the myrtle. Unlike these, however, they are devoid of petals. The fruit contains the seeds—seeds so minute, it is said, that from one pound of those of the variety *Globulus* more than one hundred and sixty thousand plants could be raised.

I have always taken a great interest in the eucalyptus, and have grown it near Dublin for several years with considerable success. I have had at one time as many as twenty fine healthy saplings of the species *Globulus*, of from ten to sixteen feet high, and one which reached to twenty-five feet, and had a stem of twenty-two inches circumference. These were all five years old. But cold is the deadly enemy of the gum-tree; and, though I had kept mine during four ordinary Irish winters, I lost them all during the almost Arctic winter of 1878–'79. I may say, in passing, that I have not been quite discouraged, and that I have again several healthy plants making good progress. My interest in the subject has received a new stimulus from a recent experience of eucalypt-culture in the wild plain known as the Campagna of Rome.

One lovely morning in last October we left our hotel hard by the

Pantheon, and in a few minutes came to the Tiber. If we except the quaint and bright costumes of many classes of the people, and the ever-changing street scenes of Rome, there is nothing in the drive of very much interest until we reach the river. Here, looking back, we see the noble structure which crowns the Capitoline Hill. The fine building on the farther bank of the river is the Hospital of St. Michele. On this side we are passing the small harbor of the steamboats which ply to Ostia. Presently, the *Marmorata*, or landing-place of the beautiful marble of Carrara, is reached. From here a drive of a few minutes brings us to the cypress-covered slope of the Protestant Cemetery, where, in the shadow of the pyramid of Cestius, lie the graves of Shelley and Keats. Apart from the interest attached to these two lowly tombs and the memories aroused by their touching epitaphs, no Englishman can visit this secluded spot and look without deep feeling upon the last resting-places of his countrymen, who have died so many hundred miles from home and friends. The cemetery is kept in order and neatness, and flowers grow upon nearly all the graves.

Our route next lay along the base of that remarkable enigma the *Monte Testaccio*, a hill as high as the London Monument or the Vendôme Column at Paris, made entirely of broken Roman pots and tiles, as old perhaps as the time of Nero ! Leaving behind this singular heap of earthenware, we thread long avenues of locust-trees, and presently, passing through the gate of St. Paul, reach the magnificent basilica of that name. Nor can I pause here to dwell upon the marvels of this noble temple, or to tell of its glorious aisles and column-supported galleries ; of its lake-like marble floor, or of the wealth of malachite, of lapis lazuli, of verde antique, of alabaster, and of gold, that has been lavished upon the decoration of its shrine. I must stop, however, to note that nowhere has the presence of the dread *malaria* made itself so obvious to myself. We had scarcely entered the church, when we became conscious of an odor which recalled at once the retort-house of a gas-works, the bilge-water on board ship, and the atmosphere of a dissecting-room ; and we were obliged to make a hasty retreat. There could be little doubt that the gaseous emanations which produced this intolerable odor were equally present in the Campagna outside, but that in the church they were pent up and concentrated.

Even did space admit, this is not the place to enter into any prolonged dissertation on the history or causes of this terrible scourge of the Roman Campagna, the fever-producing *malaria*. The name expresses the unquestionable truth, that it is a gaseous emanation from the soil ; and all that is certainly known about it may be summed up in a very few lines. The vast undulating plain known as the Campagna was ages ago overflowed by the sea, and owes it present aspect to volcanic agency. Of this the whole soil affords ample evidence.

Not only are lava, peperino, and the volcanic puzzuolana abundant, but in many places—as at Bracciano and Baccano—are to be seen the remains of ancient craters. When the Campagna was in the earliest phase of its history, it was one fertile garden, interspersed with thriving towns and villages. It was also the theatre of events which terminated in making Rome the mistress of the world. This very supremacy was the final cause of its ruin and of its present desolation. While the land remained in the possession of small holders every acre was assiduously tilled and drained ; but when it passed into the hands of large landed proprietors, who held it from the mere lust of possession, it became uncared for and uncultivated.

Filtering into a soil loaded with easily decomposed sulphur compounds, the decomposing vegetable matter finds no exit through the underlying rock. The consequences may be imagined, but, to those who have not experienced them, are not easily described. This once fertile land is now a horrid waste, untouched, except at rare intervals, by the hand of the farmer, and untenanted save by the herdsman. Even he, during the months of summer, when the malaria is at its worst, is compelled, if he will avoid the fever, to go with his flocks to the mountains. It may be mentioned, in passing, that the malaria-fever, or "Roman fever" as it has been called, has been the subject of recent investigation by Professor Tommassi-Crudelli, of Rome, who attributes it to the presence of an organism, to which the specific name of *Bacillus malariæ* has been given.

Leaving St. Paul's, we pursued for a short time the Ostian road ; and at a poor *osteria*, where chestnuts, coarse bread, and wine, were the only obtainable refreshments, our route turned to the left, along a road powdered with the reddish dust of the pozzuolana—the mineral which forms the basis of the original "Roman cement"—large masses of which rock form the roadside fences. After a drive of perhaps half an hour, we found ourselves at the Monastery of Tre Fontane (three fountains). The Abbey of the Tre Fontane comprises within its precincts three churches, of which the earliest dates from the ninth century. One of these, *San Paolo alle Tre Fontane*, gives its name to the monastery. A monk, wearing the brown robe and sandals of the Trappist order, met us at the gate. The contrast now presented between the sterile semi-volcanic country around and the smiling oasis which faces us, is striking. Here are fields which have borne good grass ; some sloping hills covered with vines ; and, directly in the foreground, almost a forest of eucalypt-trees.

We have come to learn about eucalypts ; and our guide takes quite kindly to the rôle of informant. What follows is derived from his *viva voce* teaching, from my own observation on the spot, and from a very interesting pamphlet, printed at Rome in 1879, and entitled "Culture de l'Eucalyptus aux Trois Fontanes," by M. Auguste Vallée.

Before the year 1868, the abbey was entirely deserted. It is true that a haggard-looking monk was to be found there, who acted as cicerone to visitors to the churches; but even he was obliged to sleep each night in Rome. The place attained so evil a reputation that it was locally known as "The Tomb." There are now twenty-nine Brothers attached to the monastery, all of whom sleep there each night. This remarkable result, though no doubt to a great extent due to the drainage and alteration of the character of the soil by cultivation, is unquestionably mainly owing to the planting of the eucalyptus. It would take long to tell of the heroic perseverance of these monks; of the frequent discouragements, of the labor interrupted by sickness, of the gaps made in their number by the fatal malaria, and the undaunted courage in overcoming obstacles which has culminated in the result now achieved. Let us pass to the consideration of the actual means by which so happy a change in their immediate surroundings has been brought about. At Tre Fontane are cultivated at least eleven varieties of eucalyptus. Some of these, as *E. viminalis* and *E. botryoïdes*, flourish best where the ground is naturally humid; *E. resinifera* and *E. meliodora* love best a drier soil. The variety *Globulus* (blue gum-tree) possesses a happy adaptability to nearly any possible condition of growth. At the monastery, as in most elevated parts of the Campagna, the soil is of volcanic origin, and there is not much even of that; often only eight, and rarely more than sixteen inches overlying the compact *tufa*. But, with the aid of very simple machinery, the Trappists bore into the subsoil, blast it with dynamite, and find, in the admixture of its *débris* with the arable earth, the most suitable soil for the reception of the young plants.

The seeds are sown in autumn, in a mixture of ordinary garden-earth, the soil of the country, and a little thoroughly decomposed manure. This is done in wooden boxes, which, with the object of keeping the seeds damp, are lightly covered until germination has taken place. When the young plants have attained to about two inches, they are transferred to very small flower-pots, where they remain until the time arrives for their final transplantation. The best time for this operation is in spring, because the seedlings have then quite eight months in which to gather strength against the winter cold. One precaution taken in planting is worth notice. Each plant is placed in a hole of like depth and diameter. In this way, no individual rootlet is more favored than its fellow, and, as each absorbs its soil-nutriment equally, the regularity of growth and of the final form of the tree is assured. A space of three feet is left between each seedling; but so rapid is the growth, that in the following year it is found necessary to uproot nearly one half of the plants, which finally find themselves at a distance from each other of about five feet. From this time, much care is required in weeding and particularly in sheltering from the wind, for the stem of the eucalyptus is particularly fragile, and violent storms

sometimes rage in the Campagna. The other great enemy of the tree is cold, and this offers an almost insurmountable obstacle to its successful culture in Great Britain. It seems to be well proved that most of the species will survive a winter in which the temperature does not fall lower than 23° Fahr. How fortunately circumstanced is the culture of the tree at Rome, may be learned from the fact that the mean lowest temperature registered at the observatory of the Roman College during the years 1863–'74 was 23·48°. Once only in those years a cold of 20° was registered, and even that does not seem to have injured the plants; but when, in 1875, the minimum temperature fell to 16°, the result was the loss in a single night of nearly half the plantation of the year.

But when, as at Tre Fontane, the conditions of growth are on the whole favorable, the rapidity of that growth approaches the marvelous. The mean height, for example, of three trees chosen for measurement by M. Vallée in 1879, was twenty-six feet, and the mean circumference twenty-eight inches. These trees had been planted in 1875, or in other words were little more than four years old. Other trees of eight years' growth were fifty feet high and nearly three feet in circumference at their largest part. These figures refer to *Eucalyptus globulus*, which certainly grows faster than the other species; and it must be remembered that in warmer climates the growth is even still more rapid. I have seen, for example, trees of *Eucalyptus resinifera* at Blidah in Algeria which at only five years old were already quite sixty feet high.

The question of how and why the eucalypts exercise sanitary changes so important as those which have been effected at this little oasis in the Campagna, may be best answered when two remarkable properties which characterize many of the species have been shortly considered. The first of these is the enormous quantity of water which the plant can absorb from the soil. It has been demonstrated that a square metre—which may roughly be taken as equal to a square yard—of the leaves of *Eucalyptus globulus* will exhale into the atmosphere, during twelve hours, four pints of water. Now, as this square metre of leaves—of course, the calculation includes both surfaces—weighs two and three quarter pounds, it will be easily seen that any given weight of eucalyptus-leaves can transfer from the soil to the atmosphere nearly twice that weight of water. M. Vallée does not hesitate to say that under the full breeze and sunshine—which could necessarily form no factor in such accurate experiments as those conducted by him—the evaporation of water would be equal to four or five times the weight of the leaves. One ceases to wonder at these figures, on learning that it has been found possible to count, on a square millimetre of the under surface of a single leaf of *Eucalyptus globulus*, no less than three hundred and fifty *stomata* or breathing-pores. And it now begins to be intelligible that, if such an enormous quantity of

water can be transferred from earth to air, it may be possible that an atmosphere, which without such aid would be laden with malarious exhalations, may be rendered pure by this process of leaf distillation: the putrescible constituents of the stagnant water are absorbed by the roots, and become part of the vegetable tissue of the tree.

But this is not all. Like those of the pine, the leaves of all species of eucalyptus secrete large quantities of an aromatic essential oil. It has recently been shown—and the statement has been very impressively put by Mr. Kingzett—that, under the combined action of air and moisture, oils of the turpentine class are rapidly oxidized, and that, as a result of this oxidation, large quantities of peroxide of hydrogen are produced. Now, peroxide of hydrogen is—being itself one of the most potent oxidizers known—a very active disinfectant; and, as the leaves of some species of eucalyptus contain in each hundred pounds from three to six pounds of essential oil, we can hardly avoid the conclusion that the oxygen-carrying property of the oil is an important element in the malaria-destroying power of the genus. Moreover, the oxidation of the oil is attended by the formation of large quantities of substances analogous in their properties to camphor, and the reputation of camphor as an hygienic agent seems sufficiently well founded to allow us to admit at least the possibility of these bodies playing some part in so beneficent a scheme.

Before closing this paper, it may be well to note that the Trappist monks of the Tre Fontane attach much importance to the regular use of an infusion of eucalyptus-leaves as a daily beverage. The tincture of eucalyptus is said to be useful in intermittent fevers, though of course inferior to quinine. As we threaded the coast-line *via* Civita Vecchia to Leghorn, we could not help being struck by the fact that the precincts of all the railway-stations were thickly planted with eucalypts. Since our return, I learn with much gratification that the Italian Government have given a grant of land to the Trappists, and have also afforded them the aid of convict-labor to a considerable extent for the establishment of a new plantation. And looking back not only at what has been actually accomplished during the past ten years, but to the important fund of information which has been accumulated, one can only look forward hopefully and with encouragement to the future of the eucalyptus in the Roman Campagna.—*Chambers's Journal.*

INFLUENCE OF THE POST AND TELEGRAPH ON INTERNATIONAL RELATIONS.

BY C. M. DUNBAR.

IT is a beautiful theory that man was made for society; but it is an eminently better one that society was made for man. Man was necessarily in existence before society. He contains within himself all the virtues that are an ornament to society, all the elements that strengthen government. And government, and even society itself, however consequential they may appear to the view of the haughty and superficial observer, are, notwithstanding, only means to an end. That end is the betterment of the material, moral, and intellectual conditions of the individuals composing that society and state; to confer upon them, as far as possible, the greatest amount of happiness. For this society was formed, and for this it is maintained. To protect the individual in his pursuit of happiness, governments were instituted, and when they no longer subserve that chief end they become obsolete.

The primitive and fundamental type of governmental organization and authority is the family. Therein the natural affections cement the compact between the different members of the household. Nature also compels the observance of the different duties due from each member. The duties are mutual. The natural obligation of the head of the family is to provide for the maintenance of those whom he has been instrumental in bringing into the world. And they, on their part, are bound to yield to him the respect naturally due him, and obedience in all matters in which his years of experience render him more fit to judge. This might be said to be the condition of a family in a state of nature. Such is the primitive form of government—one established by nature itself. Individuals unite into families, families into clans, clans into villages, villages into provinces, and these into states. All formations subsequent to that of the family are artificial; but the duties of the members of these corporations to each other and to their rulers or public servants, and the latter to the individual members, are analogous to those of members of a family. It is not the writer's intention to enter here into an extensive view or review of the theory of the social compact, or into a discussion of its fallacy or plausibility; suffice it to say that it illustrates the principle that the people are the source of governmental authority—a principle that, at least, is recognized by all well-informed Americans.

The different forms of political institutions in existence are due to the different phases of nature with which different peoples have been surrounded. Even the various forms of religious worship, in most cases, owe their origin to some cause produced by nature, whether of

climate, soil, or atmosphere peculiar to the locality of the people professing and practicing those forms of religion. Consequently, the diversity of customs and habits of different peoples should give rise to rights and duties differing in nature and degree between the diverse political divisions. Now, what is the duty of a people in such cases in their relations with each other? It is the duty of a good father to love and protect the members of his family before other persons; his care and solicitude should begin with his own. Yet he owes a duty to his kind—that is, to help others when required, if he can do so without injury to himself or those depending on him. We may say that men in a state of nature would be compelled by force of circumstances to the observance of these rules. How is it with regard to states? Their first duty is to look to the welfare of their own citizens; yet they should remember that individuals of whatever nationality have natural and inherent rights that should be everywhere recognized, since the exercise of these rights is necessary to existence. It is true that an individual, passing from one state into another, can not carry with him rights not possessed by the citizens of the state he enters, especially if their exercise would interfere with the political or civil rights of the natives. Thus it is that rights will always vary from one people to another. Sometimes the laws and rights vary in the state itself; there frequently arises a diversity of laws and customs between the different provinces of the same country: as in ancient France, which was formed out of a number of feudal sovereignties, each having its particular law, and giving rise to frequent conflicts between different customs. A like cause produced a like effect in the German Empire: the law varied from one city to another, and even from one street to another in the same city. Another difficulty arises. How are we to determine between these conflicting laws? The law of nations is the same, theoretically at least, for all humanity. Private international law, which is a branch of the law of nations, has also a tendency to unity—not that it has for an ideal the uniformity of the law of all portions of the human race; such would be too dreamy an idea. But the rules which serve to solve these conflicts can and should be the same the world over, notwithstanding the diversity of legislation. It is this unity that private international law has sought, and now seeks to establish. How can it be realized? It can not be formed, like the civil law of each people, by legislation, or command of a superior authority, since independent sovereign nations recognize no authority superior to themselves. Each legislature can not make laws that will be operative beyond the limits of the territory over which it has legislative power. Here, again, we see the analogy between private international law and the law of nations. Nations, like individuals, have their personality; between individuals, the juridical disputes arise either upon a contract, or on account of a wrong committed; it is the same

with nations: they can not be bound but by their own consent; hence the treaties which form the basis of the positive law of nations. It is also by concurrence of wills that nations obligate themselves to observe certain rules looking to the conflicts likely to arise in the application of the particular laws of the different states. Agreements are not necessarily expressed; a tacit consent suffices to form an agreement. It is the same in international conventions: the greater part of those which form the basis of the law of nations are tacit agreements; the law of nations is principally a customary law, which is founded on the tacit consent of the peoples. That which is true of the law of nations is also true of the private international law: certain rules common to all nations can not be formed but by a concurrence of consent, express or implied. On this particular point the treaties are very few; and these, are particular agreements between the two states, having no relation but to the interests of the contracting parties. There remain only the customs which are established by implied general consent. This is almost the sole source of the private international law. There is, however, a vast difference between the international customs and the customs which form one of the sources of the civil law of each state. The latter have the force of law, until abrogated by some particular statutory enactment; they are the implied expression of the sovereign will of the nation—they might be called tacit laws. Not so with the international customary right. Since it is a question of sovereignties, they can not, correctly speaking, be called laws; hence the nations could not be bound to recognize a legislative authority higher than their own. The international customs do not hold the place of laws—they hold the place of agreements; they are implied treaties. How are these implied treaties formed? This is a capital question, and as difficult as it is important. Ordinarily international customs are considered as being of the same nature as national customs. This is not the case: the former are tacit treaties, while the latter are tacit laws, and there is a great difference between treaties and laws; the treaties are formed by a concourse of wills, and the laws are promulgated by way of commandment; the treaties differ in their essence from laws; the conditions, therefore, under which tacit treaties can be formed should also differ from the conditions under which implied laws are formed. The intimate lien which exists between the private international law and the law of nations brings up a redoubtable problem. Is there a law of nations? Those who deny it have strong reasons for doubting. Can there be a law without a legislature; without a tribunal to apply the law, and without any authority to execute the sentence of the court? And, in this matter of the law of nations, where are the legislative, executive, and judicial powers? It may be said that right is necessarily anterior to the law, that it results from the nature of man and civil societies: if the relations between individuals are necessarily

regulated by right, it must or should be the same with international relations. It is ever the case that the law of nations has not the certainty or authority of the civil or public law, which is almost everywhere codified, while the law of nations can not be, inasmuch as huumanity is not organized. The arguments which may be advanced against the existence of the law of nations are, in a measure, applicable to the private international law. If the latter is a branch of the former, it may be said that what is true of the one is true of the other. There is only this difference, that the law of nations regulates public interests, while the private international law is virtually identical with the civil law of each state ; and only occupies itself with private interests. This difference is considerable, and leads to important consequences. The existence of a law, properly so called, regulating the relations of nations with each other is, at best, problematical ; as yet it is force alone which decides their disputes. This is not the case with the private international laws of different nations. It is they, not the nations, which are on trial ; it is individuals, and the courts, and not the sword, which must decide their differences.

In order that we have a private international law, man must enjoy everywhere the same rights whatever be his nationality—that is, he must enjoy everywhere equally the same civil or private rights. Now, what are civil or private rights ? Certain faculties, the exercise of which is necessary to man for his physical, intellectual, and moral existence. Can a man exercise these everywhere, or are they limited to the state in which he was born ? Man is not an incorporeal hereditament, attached to the soil on which he was born, but is a citizen of the world ; he establishes himself where circumstances, or his faculties, call him ; even without quitting his natal soil he can enter into relation with the entire world. Why should his natural rights stop at the frontiers of his country ? Is it because humanity is divided into different nations, each having its separate organization and particular laws ? It is true that the division of the human race into distinct nations has this for an effect, that each man has a distinct country, in the bosom of which he exercises the political rights that pertain to the citizen, but he can not enjoy these rights outside of his own country ; the quality of citizen gives exclusive rights and imposes exclusive duties.

But the political separation of states has nothing in common with the enjoyment of private rights : if it is impossible for me to be an elector or juror in any one state or country, that is no reason why I should not become proprietor wherever it pleased me to purchase. The exclusion from the enjoyment of political rights should not also necessarily exclude the enjoyment of private rights. A person should enjoy everywhere the same civil rights, since they are an accessory of life. The diversity of states and their constitutions should be no obstacle, for these rights are not due to the foreigner as a citizen ; they

are due to him as a man, and he is a man everywhere. The first condition necessary, in order that man may perfect himself, is that he enjoy all the natural and legal faculties without which he could not live. The rights of man, therefore, are independent of the diversity of states; they appertain to him simply as a man—that is to say, they belong to him everywhere.

The equality of the foreigner and the citizen is the basis of the private international law: if the foreigner did not enjoy any civil rights, it would not be a question by what law his rights were to be determined; in that case not only would the international law have no reason of being, but it would be impossible. This is why the private international law is of such recent date. In fact, scarcely any two of the writers upon it agree as to its nature and scope. Some authors, convinced of the inanity of theory, have believed that the law should rest upon facts; in presence of the extreme diversity of national legislation, they have appealed to the comity that peoples should observe in their relations with each other; each in its legislation having an interest in looking to the welfare of the foreigner, inasmuch as its own citizens are taken into account by the foreign laws. This is nothing less than the doctrine of interest—a doctrine false in philosophy and false in law; interest is not a principle, it is a fact, and a variable fact according to the circumstances and the passions. The right, on the contrary, should rule the facts; it is a contradiction of terms to pretend that interest, always hostile, will put an end to the eternal conflicts which it begets. On the contrary, it will be seen that the facts are the great obstacle which this science has to contend with. How will a union be established in the midst of this infinite diversity? It is the contrariety and diversity of laws that demand application of the judge: is it the national law which the judge should apply, or that of the parties to the suit? And what will be done in case the parties belong to different nationalities? Shall we take into account the law of the place where the subject of the dispute is situated? Shall we distinguish whether they are chattels or immovables? If it is a question arising upon contract, shall we have recourse to the law of the place where the contract is made, or where it is to be executed? Shall we give a preference to the law of the debtor or to that of the creditor? If there is involved the validity of instruments in writing, shall we follow the law of the place where the writings were made? By what principle shall a judge decide in this sea of doubts? These are the principles sought by the private international law.

Private international law, considered as a positive law, reposes on the agreements expressed or implied, which are entered into between sovereign nations. Treaties alone can put an end to the war of conflicting interests and diverse laws. There is but one means of conciliating nations who recognize no superior authority, and that is by way of concurrence of consent. Italy, under the inspiration of Man-

cini, has inscribed in her code the principles of nationality and the consequences that flow therefrom. Mancini says there must be treaties in order that the interest of foreigners be maintained and full justice done them on an equal footing with the citizens. If he has not completely succeeded in his mission, it is because the times are not ripe for the realization of his ideas. This is not a new dream of perpetual peace, for the true ideal is not peace, but the reign of right; and certainly there is nothing Utopian in the hope that peoples will understand the regulation of interests purely private, and having little or no connection with these greater interests for which, it is to be feared, the resort to arms will always be a painful necessity. If this attempt of Mancini has been premature, it has not on that account been useless. It has opened the only way to a solution of the difficulties which every day increase as international relations multiply.

In our days, through the progress of the physical sciences, and their coöperation with modern diplomacy, international relations have undergone a veritable transformation. Communications between the most distant countries are now more sure and easy than they were in the last century between two provinces of the same state. A letter from any part of the United States to Rome now costs less than a letter from one town to another, ten miles distant, did sixty years ago. The merchants of New York, Cincinnati, and Chicago, and even San Francisco, negotiate as easily with the merchants of Paris, London, or Liverpool as with those of Buffalo, Philadelphia, or New Orleans. We employ each day, for the satisfaction of our wants, the products of the most distant countries with as much facility as those of our own soil. Undoubtedly science has done a vast amount in this prodigious development of international intercourse; it is science which has furnished us steam and electricity, for diminishing distances, and bringing peoples into closer relations. Science, it is true, can not do everything; it should be seconded by the law to produce all the advantages of which it is capable. The means of communication furnished by it—the railroads, the steamboats, and the telegraph-lines—would have but a limited sphere of action, if the States were isolated one from another. The legal barriers that formerly existed between peoples should be removed at the same time as the natural barriers, and this is really taking place, for, as science progresses and material interests become more developed, the ancient restrictive rules on immigration are successively modified, as also are the regulations on the legal condition of foreigners, on the necessity of passports, etc. But this alone will not suffice: sometimes it is necessary that governments mutually aid each other in the attainment of a result beneficial to all; such, for example, as the extradition of fugitives from justice. The tendency is to create or regulate the relations between civilized countries in such a way that, while the sovereignty and independence of each is guaranteed, the general interests, having a cosmopolitan char-

acter, will be found as satisfactory as if they were those of a single state. In later years the development and application of this general idea, through the progress made by the physical sciences, have far exceeded the hopes of the most sanguine. Take, for example, the post and the telegraph. A few years ago the wildest visionary would never have dreamed of the cordiality which to-day exists between the different peoples in their international relations. The postal and telegraphic services have contributed largely to this result. The same treaty unites Turkey and Russia, France and Germany, Montenegro and the United States.

Down to 1830 the postal system was not very well developed even between different parts of the same country; and of course was much less efficient between different countries, where greater obstacles to its progress would naturally be encountered. It was only after this period and in consequence of the new relations to which a long peace had given rise, aided by the development of means of communication by land and sea, that the different countries felt the necessity of regulating their international postal communications. Without studying those treaties as such, let us take a view of their object and utility.

Two countries who wish to regulate their international postal exchanges in a secure way must come to an understanding on the means of transportation they will use, whether it is by railroad, stage, steamers, or sailing-vessels, and what contribution to the expense of carriage will be made by the respective parties to the contract. The questions to be considered are: What will be the expense of mails thus transported? Will the postage be paid by the sender or receiver? In what proportion will the expenses be borne by the offices coöperating in this transportation? It is on these points also that naturally arise the chief difficulties, in consequence of the conflicting interests of the contracting parties, each viewing the matter from his particular standpoint, and each seeking to obtain the greatest benefits from the regulations adopted.

In general, two postal administrations do not content themselves with exchanging mails directly between the two countries; each of them, generally, has existing arrangements with other states which they use as an intermediary. For instance, France, on account of its geographical situation, plays this rôle for a number of countries; it serves as an intermediary for communications between the countries of Spain, Italy, Switzerland, Germany, Belgium, and Great Britain. A letter may have to traverse many countries to arrive at its destination: thus, a letter addressed from Lisbon to the Hague passes through Spain, France, and Belgium; it has three intermediate countries to traverse. Therefore, regulations must be made between the services of direct exchange and those of transit. By transit we mean the countries traversed; thus, the French transit is necessary to communicate between the United States and Italy, under present regula-

tions. Another matter to be considered is the distinction between the maritime and terrestrial transits; the former is ordinarily more expensive than the latter, in consequence of the subsidies granted by many countries to steamers on their navigable rivers, and in some countries the railroads transport mail-bags gratuitously. The treaties have therefore to regulate the transit, the manner in which it is to be effected, and the remuneration. It must also regulate a great many other matters: for instance, what will be carried by the mails? Formerly, at great distances, letters only were exchanged; now journals and pamphlets of every kind are carried, packages of merchandise, and even money and valuables.

The system of isolated postal treaties between different countries has had its day, and what progress was possible under it has already been attained. Certain countries, which until recently remained outside of the international movement, have now entered into it with ardor. Thus in the year 1872 Russia, besides her postal treaty with France, signed postal agreements with Germany, Belgium, Italy, Holland, Denmark, Sweden, Norway, and Switzerland. By an examination of the numerous arrangements which at this period were formed for postal relations, it is easy to ascertain a uniform tendency toward the development of international exchanges by lowering the rates of postage and by the simplification of operations. In 1862 the postal administration of the United States called the attention of foreign postal departments to this matter, and indicated the number of obstacles to foreign correspondence resulting from the difference in the principles as well as in the detail of postal arrangements—obstacles that could not be remedied but by an international concert of action. Consequently, it invited the members of the postal departments of the different nations to an international conference. This conference took place at Paris in May, 1863, and was composed of delegates from fifteen countries; its object, as declared by its president, was "not to discuss or to regulate certain practical facts which pertain to a sphere of negotiation beyond our powers, but to argue, or at least to consider and proclaim, certain general principles, certain speculative doctrines, which hereafter we may be forced to adopt in the interest of the public and of the Treasuries of our respective Governments." The different problems of the postal exchanges were discussed with considerable acumen, and the result of the deliberations was the enunciation of the general principles, which were "of a nature to facilitate the relations of people with each other by way of the post, and to serve as a basis to international conventions looking to a regulation of these relations." This conference of 1863, although bringing about no immediate result, had nevertheless a considerable influence: it showed the possibility of an understanding and the advantages of discussion. Some of the ideas recommended soon afterward passed into practice. With the progress of time their practicability became more apparent; and a new conference was called,

not only to exchange ideas, but to lay the foundation for an actual treaty. Since 1865 there has been a Telegraphic Union. Why not also have a Postal Union? As a consequence of these negotiations, which were interrupted by the Franco-Prussian War, and subsequently resumed, Switzerland convoked at Berne the delegates of the European Governments and of the United States on the 1st of September, 1873. Different powers, principal among which were France and Russia, having manifested an intention to abstain from the conference, it was adjourned. It reconvened September 15, 1874; and included delegates from all the European powers, from Egypt, and the United States. Notwithstanding the numerous difficulties met with, among which may be mentioned the differences resulting from the wide separation of some of the countries, the enormous inequality of their territories, a great diversity of views on economic and financial points, and, finally, the power, always strong, of existing arrangements, a Postal Union was finally formed, after fifteen sessions of the convention.

The delegates were many of them general directors of the postal departments of their respective countries. Those of Germany played a preponderating rôle in the Congress, because it was from them came the initiative of the reünion, and the discussion bore largely on their project; the Belgian delegates also took an active part. The delegates of France and Great Britain were, on the contrary, not very active in the formation of the Union. France, for divers reasons, could not view the project with favor; she was principally kept back by fear of the consequences to her finances that would follow the signing of the treaty, so terrible was the strain on her exchequer of the trying events of 1870–'71. Her delegates took no part in the discussions, nor in the voting on the different provisions of the treaty; but the pressure of public opinion compelled her to sign the treaty which was concluded between the powers on the 9th of October, 1874.

Besides the treaty, the delegates also signed a detailed regulation for the execution of the treaty. There is this difference between the two acts: the first can not be modified or amended but by the action of representatives fortified with the full powers of their Governments; while the other can be agreed upon between the administrators of the various postal departments. The first is a diplomatic act, the second an administrative arrangement. The same course was followed at St. Petersburg, in 1875, in establishing the Telegraphic Union.

The Union is not limited to the countries signing the Berne treaty. That treaty provided for the accession of new members; and since 1874 other nations than the original contracting parties have joined it, and in the near future we may see a universal postal association, embracing the entire world.

Turkey, on account of its peculiar international situation, is distinguished in this treaty from the other contracting parties, inasmuch as its foreign correspondence is made through foreign offices. Thus

at Constantinople there are bureaus established by France, Austria, Russia, England, and Germany, who occupy themselves with the international postal service, in which Turkey takes no part. At Berne the Ottoman delegate protested against this state of things, declaring that his Government wished to enter definitely into its rights, and that, besides, it was ready to do all that was necessary to carry out the requirements of the international postal service. The response to this was a demurrer, on the ground that the protest was a matter of which the conference could not take cognizance, and one that should be regulated between Turkey and the different states interested.

The general principle of the treaty is thus stated in its opening article: "The countries between which the present treaty is concluded will form, under the designation of General Postal Union, one single postal territory for the reciprocal exchange of correspondences between their postal departments."

SKETCH OF EDWARD D. COPE.

THOUGH still a young man, having just entered on his prime, Professor Cope is widely known for his enthusiasm and industry in scientific pursuits. Already he has accomplished an amount of original work in his chosen field of investigation that would do credit to an ordinary lifetime, and that justly entitles him to the place he now holds among the foremost of American biologists.

Edward Drinker Cope was born in the city of Philadelphia, in 1840. He is of English and French descent, and his ancestry on both sides is represented by names once prominent in the histories of their respective countries. As a boy he was particularly interested in scientific studies, and also showed an early aptitude in the use of language, which has since developed into that remarkable power of lucid and fluent expression, even on the most abstruse of topics, for which he is now distinguished. He began to write on his favorite subjects when only sixteen; but, as he was then occupied with what others had done, and presumably had nothing new to say, his writing attracted little if any public attention before he was twenty-five. After eighteen he studied with a private tutor; subsequently graduated from the University of Pennsylvania; studied comparative anatomy in the Academy of Sciences of Philadelphia, in the Smithsonian Institution in 1859, and in Europe in 1863–'64; and became Professor of Natural Science in Haverford College in 1866. The most important part of his scientific work is comprised in his paleontological studies, and the papers he has prepared concerning them. He began his explorations in field geology in the Cretaceous green-sand of New Jer-

sey in 1866, where he discovered fifty-eight species of vertebrates new to science, including the remarkable dinosaur, *Loelaps aquilungis*. Next he turned his attention to the Miocene strata of Maryland and North Carolina, where he found many cetaceans, of which half the species were new, and some were of great size. He also surveyed the Trias of the Atlantic slope, and contributed, by the identification of the genus *Belodon*, of Von Meyer, in North Carolina and Pennsylvania, to fix the determination of its age. In 1868 he was engaged, in connection with the geological survey of Ohio, in the examination of the characters of the air-breathing vertebrates, of which he determined thirty-four species of fourteen genera, and defined the order *Stegocephali*.

His Western explorations were begun in 1870, when he visited the Cretaceous region of western Kansas, and found there some remarkable forms of fish, and the *Liodon* and *Elasmosaurus*, the largest known swimming saurians. His next excursion was for the exploration in 1872 of the Eocene Bad Lands of the tributaries of Green River, in Wyoming Territory. Mr. J. King at one time made these beds Miocene, but Professor Cope claims to be the first to determine that they were Eocene. He found in them the remains of a huge mammal, with three pairs of osseous horns, or processes, on the skull, to which he gave the name of *Loxolophodon cornutus*. From this and other material, obtained at the time, he was able to determine the true character of the *Dinocerata*, and to refer the groups to the *Proboscidæ* as a sub-order. In the next year, as paleontologist of Dr. Hayden's Survey of the Territories, he conducted an expedition into northeast Colorado for the exploration of the White River beds. Among his discoveries here were five species of the new genus *Symborodon*, creatures of gigantic size, with long, horn-like processes on the front of the skull, and another animal about as large as a squirrel. In 1874, as paleontologist to Lieutenant Wheeler's geographical surveys, he took part in studying the geology of northwestern and central New Mexico. The geology of the Northwest region, which, in the estimation of Professor Cope, had been previously misunderstood, was developed, and a great tract of Eocene sedimentary rocks identified. A rich vertebrate fauna was found, in its main features identical with the Suessonian of Western Europe. The primitive type of the carnivora was first defined under the name *Creadonta*, and a gigantic bird also discovered. The same expedition explored the red beds of the Rocky Mountains and the Loup Fork bed of the Santa Fé. In 1875 Professor Cope determined that the vertebrates of this formation were reptiles and not mammals, as had been supposed, and their age was therefore set down as cretaceous instead of tertiary. This expedition, together with the previous one in the same horizon in Colorado, yielded forty new species, many of which were dinosaurs of high organization. Some of the herbivorous forms were found to have an

exceedingly complex dentition, arranged in magazines, containing in some instances as many as two thousand teeth. A new group of saurians and several batrachians were also discovered. Explorations were begun in the Jurassic beds of the upper Arkansas River, in 1877, which yielded some of the largest crocodilians known. Other expeditions were sent out into the Permian regions of Texas and into Montana and Nebraska. In the latter he discovered a new geological horizon between White River (lower) and Loup Fork (upper) Miocene, from which several species of peculiar character were obtained. Two expeditions to explore the Loup Fork beds of Kansas obtained numerous reptiles, and mammals, including horses, camels, a new mastodon, and two new rhinoceroses. Explorations in Oregon were begun by parties sent out in 1877, and Professor Cope visited the field in 1879, partly to examine the material that had been collected, among which he found many fine specimens, and partly to study the Pliocene deposit of that region, which was found remarkable for the prodigious number of the bones of birds it contained and for the occurrence of flint implements. In all of these expeditions six hundred and thirty-five new species were discovered, including one hundred fishes, one hundred and seventy-five reptiles, ten birds, and three hundred and fifty mammals, from which have been constituted the extinct orders *Actinochiri* (fishes), *Stegocephali* (batrachians), *Charistodera*, *Pythonomorpha*, and *Theromorpha* (reptiles), *Tæniodonta*, *Credonta*, and *Amblypoda* (mammals).

Professor Cope has also contributed to the definite determination of the relative ages of the horizons of the interior of the continent as named by American geologists, and to their reference to corresponding horizons on the European scale, beginning with the Permian and including the Niobrara and Laramie Cretaceous, the Wahsatch, Bridger, White River, Truckee, Loup Fork, and Pliocene Tertiary formations.

The scientific writings of Professor Cope are quite voluminous, and mainly technical in characterr. They relate to a variety of departments of natural history. The full list of them includes nearly three hundred titles of papers which have been published in the official reports of the Government surveys, the proceedings of the Philadelphia Academy of Sciences, of the American Philosophical Society, the American Association for the Advancement of Science, in the "American Journal of Science and Arts," the "American Naturalist," the "Penn Monthly," and through other channels. By far the largest number of these papers relate to the reptiles and fishes discovered in the different geological formations, extending from the Atlantic coast to the Rocky Mountains, in the surveys of which he has participated. Probably the next largest number concern the cetaceans and mammalia of those formations. About a dozen of them relate to the reptiles and fishes of tropical America; half as many embody studies of the fauna, living and fossil, of caves. Many papers describe living reptiles and fishes. More

than thirty papers, published separately in advance by Professor Cope as "Paleontological Bulletins," were included in the official reports of the Government geological surveys of the Territories as special reports of the departments of the work which were assigned to him, including general geology, and the identification, classification, and descriptions of new fossils and species. Among papers which do not fall exactly under any of these heads may be mentioned those "On the Fresh-Water Origin of Certain Deposits in West New Jersey"; "The Birds of Palestine and Panama compared"; "On some New and Little-known Myriapoda from the Southern Alleghanies"; "Intelligence in Monkeys"; "The Significance of Paleontology"; "Biological Research in the United States"; articles on "Osteology" and "Comparative Anatomy" in Johnson's "Cyclopædia"; "Excursions of the Geological Society of France"; "The Fauna of the Lowest Tertiary of France"; "A New Deer from Indiana"; "The Modern Museum"; "Pliocene Man," etc. His papers on evolution form a separate department. Professor Cope has been a diligent student of this subject, and has opinions of his own upon it. Among his principal contributions to its literature are: "On the Origin of Genera" (1868); "Method of Creation of Organic Types" (1871); "Evolution and its Consequences" (1872); "Homologies and Origin of the Molar Teeth of Mammalia Educabilia" (1874); "Consciousness in Evolution" (1875); "Relation of Man to Tertiary Mammalia" (1875); "On the Theory of Evolution" (1876); "The Origin of the Will" (1877); "The Relation of Animal Motion to Animal Evolution" (1878); and "A Review of the Modern Doctrine of Evolution" (1879).

Professor Cope was for a long time Secretary and Curator of the Academy of Natural Sciences, of Philadelphia, and was chief of the Department of Organic Material of the Permanent Exposition of that city. He received the Bigsby gold medal of the Royal Geological Society of Great Britain in 1879; is a member of the Geological Society of France, and of the American Association for the Advancement of Science.

EDITOR'S TABLE.

THE PHOTOPHONE IN RESEARCH.

THE elegant research of Professor Tyndall, which we publish in the present number, will well repay the careful attention of our readers. It is of interest, not only on account of the very complete confirmation of results previously obtained by this physicist, but also on account of the novel method employed, and the promise this gives of wide utility. The photophone is barely six months old, but these experiments show that it already has a large field of usefulness before it, and it is, perhaps, not too much to expect that it will prove to be one of the most delicate instruments at the command of the physicist. The experiments are further interesting for the very conclusive demonstration they afford of the causes to which the action of the instrument is due. From the first, Professor Tyndall states, he was convinced that the sounds given out by bodies upon which the intermittent beam of light impinged were due to their expansion and contraction under the influence of radiant heat, and this opinion is most fully borne out by the results obtained. The experiments, while showing the great delicacy of this beautiful instrument of Professor Bell, also incidentally show that some of the expectations with regard to it are unfounded. One of these is, that with it sounds upon the sun may be heard. The fallacy of this has been recently pointed out, and the arrangement of the apparatus adopted by Professor Tyndall clearly exhibits it. It consists in assuming that the sound given out by the absorptive body is the reproduction of a previous sound, while in reality all that is necessary is that the impinging beam be intermittent—its variations may be produced in any manner whatever.

Of the results of previous experiments confirmed by this later research, the most important are those regarding the behavior of dry air and the vapor of water toward radiant heat. By a long series of beautiful and refined experiments, Professor Tyndall had shown that the former was perfectly transparent to such heat, while water-vapor was a powerful absorbent of it. These results have been disputed by other experimenters, and it needed, to definitely settle the controversy, some more delicate method of testing these substances than that furnished by the instruments heretofore at command. This has been supplied by this latest acquisition of science, and the first use of it appears to fully sustain Professor Tyndall's position.

BOOK PHYSIOLOGY ABROAD.

WE often hear subdued expressions of doubt as to the quality of the physiological teaching prevalent in girls' schools. It is intimated that the knowledge the pupils get upon this subject is generally of a very loose and vague sort, so as to be but of little practical use. It is objected to what girls learn about in their physiological studies, that it is not entitled to be called knowledge at all—that is, they do not really *know* what they are studying about, but only remember certain statements as well as they can, while the information they get is not of a kind fit to be used. Whatever may be the fact in regard to our own schools, it is pretty certain that the physiology taught to girls in some of the English schools is marked with all the bad qualities sometimes ascribed to our own.

The London "Globe" gives a ludicrous illustration of the results of phys-

iological teaching in the girls' schools of the English metropolis. It seems that the National Health Society, laudably desirous of promoting the increase of practical physiological intelligence, offered prizes to be competed for by the pupils of the girls' schools under the control of the London School Board. The response, however, was not very lively. Out of two hundred and thirty-four schools only eleven sent competitors, it being presumed that in the other schools physiology is either not taught at all or so poorly taught that there was no emulation. The eleven schools which were represented in the examination, we are to suppose, were the best girls' schools under the jurisdiction of the board. Two hundred and fifteen girls attended and competed for the prizes, the examination being conducted by Mr. McWilliam, who reported the result to the London School Board.

The "Globe" says: "Many of the children appear to have been utterly unable to understand the terms of the questions. 'Mention any occupations which you consider to be injurious to health, giving reasons for your answer.' This question, Mr. McWilliam says, especially appears to have puzzled them. One girl's complete answer to this question is, 'When you have a illness it makes your health bad, as well as having a disease.' Another says, 'Occupations which are injurious to health are carbolic acid gas which is impure blood.' Another complete answer is, 'We ought to go in the country for a few weeks to take plenty of fresh air to make us healthy and strong every year.' Another complete answer is, 'Why the heart, lungs, blood, which is very dangerous.' The word 'function' was also a great puzzle. Very many answered that the skin discharges a function called perspiration. One girl says, 'The function of the heart is between the lungs.' Another says: 'What is the function of the heart? Thorax.' Another girl, in answer to the sixth question says, 'The process of digestion is: We should never eat fat, because the food does not digest.'

"Another class of errors is that of exaggerated statements, one girl answering, 'A stone-mason's work is injurious, because when he is chipping he breathes in all the little chips, and then they are taken into the lungs.' Another says, 'A bootmaker's trade is very injurious, because the bootmakers always press the boots against the thorax, and therefore it presses the thorax in and it touches the heart, and if they do not die they are cripples for life.' Several girls insist that every carpenter or mason should wear a pad over the mouth; and one girl says that, if a sawyer does not wear spectacles, he will be sure to lose his eyesight. Finally, one girl declares that 'all mechanical work is injurious to health.' Another child says that 'in impure air there is not any oxygen, it is all carbonic acid gas.' Another says that if we do not wash ourselves 'in one or two days all the perspiration will turn into sores.'

"One girl states that 'when food is swallowed it passes through the windpipe and stops at the right side, some of it goes to make blood, and what is not wanted passes into the alimentary canal.' Another girl from the same school says, 'Venous blood is of a dark black color, and when it reaches the heart it is made by the heart a bright red color.' Several girls from the same school repeat this last error. Another girl says, 'The chyle flows up the middle of the backbone and reaches the heart, where it meets the oxygen and is purified.' Another says, 'The work of the heart is to repair the different organs in about half a minute.' Another says: 'We have an upper and a lower skin; the lower skin moves at its will, and the upper skin moves when we do.'"

THE TYNDALL TRUST FUND.

It may be recollected that, at the close of his lectures in this country, 1872–'73, Professor Tyndall left all the money he had received, except what was consumed in expenses, as a trust, the income of which was to be devoted to the assistance of American students in physics desirous of completing their studies in Germany. The fund was intended, of course, for those who were without sufficient means of their own for the purpose, and was to be only available for such students as had shown an inclination for original studies, and some aptitude and capacity in pursuing them. Trustees were appointed to take charge of the fund, which was at first so small that it was thought best to let it accumulate until the income became sufficient to give a moderate support to two students. The increase of the capital has now reached a point at which the income of the trust becomes applicable for its purpose.

The original trustees appointed by Professor Tyndall were Professor Joseph Henry, of Washington; General Hector Tyndale, of Philadelphia; and E. L. Youmans, of New York. The two former are dead, and President F. A. P. Barnard, of Columbia College, New York, and Professor Joseph Lovering, of Harvard University, Cambridge, have been appointed in their places. Applications for the benefit of the trust can be made to either of the trustees.

LITERARY NOTICES.

Studies from the Biological Laboratory of Johns Hopkins University. Parts I, II, and IV, and Scientific Results of the Chesapeake Zoölogical Laboratory, Session of 1878, forming Part III. Baltimore: John Murphy & Co. 1880. Price, per Part, $1.00.

We can not too heartily congratulate Johns Hopkins University in being able to publish a work of such great value as the one before us. Its fame abroad will rest almost solely on these careful memoirs, which have doubtless found their way into the scientific libraries of the Old World, and in return for which the university must have gained many additions to its own shelves. Through the liberal recognition of the value of scientific work, the trustees of the university can lay claim to a publication having already reached four parts, numbering over five hundred pages, and illustrated by forty admirable plates.

The first part contains an elaborate paper on "The Normal Respiratory Movements of the Frog, and the Influence upon its Respiratory Center of Stimulation of the Optic Lobes," by Dr. H. Newell Martin, Professor of Biology in the University. Among the many contradictory accounts in regard to the mechanism of this process, Professor Martin says that the first detailed description by Townson in 1794 is essentially correct in all respects. After giving the conclusions of various authors, he details his own experiments, illustrated by diagrams. These consisted in carefully removing the central lobes and optic thalami, and, after observing the diagram made by the animal's respiratory movements, he stimulated the anterior cut ends of the optic lobes by a crystal of salt, and carefully noted the results. He found that irritation of the optic lobes diminished the irritability of the inspiratory center, and increased that of the expiratory center. In conclusion he points out that the results of chemical stimulation of the corpora quadrigemina in the mammal, as described by Ferrier, "correspond with the results of chemical stimulation of corresponding parts in the frog."

The next memoir, by Henry Sewell, B. Sc., is on "The Development and Regeneration of the Gastric Glandular Epithelium during Fœtal Life and after Birth." A prolonged study of the different cells in the glands of the adult stomach having failed to give the author such insight into their various functions as he desired, recourse was had to the stomachs of embryos; his material consisting mostly of embryo cats and dogs. He shows in summing up that "the stomach-glands are formed by ridge-like outgrowths from the surface of the mucous membrane. The hypoblastic cells, at first in a single layer, become several

layers thick before the formation of the ridges, and become single again over these. . . . By the intersection of the ridges, pits are left, which are the gland-pouches." The "ovoid" cells are first specalized and later the central cells, the latter alone being concerned in the formation of pepsin.

The third article is by Professor Martin and Dr. W. D. Booker. Its subject is "The Influence of Stimulation of the Mid-Brain upon the Respiratory Rhythm of the Mammal." Having found that chemical stimulation of the mid-brain of the frog caused accelerated or tetanic inspiratory and impeded expiratory movements, experiments were made on rabbits to see if the same phenomena were exhibited by mammals. By an ingenious arrangement the animal was made to breathe into a jar, the aperture of which was covered by an elastic membrane, and through a connecting lever was made to record, on a revolving cylinder, all the respiratory movements. The stimulus applied was by means of electrodes, connected with a secondary coil of a Du Bois induction apparatus. The current from a single carbou-bichromate cell was sent through the primary coil.

Reference must be made to this memoir for further details regarding the experimental methods employed. The general results are summed up as follows: "There lies deep in the mid-brain of the rabbit, beneath the posterior corpora quadrigemina and close to the *iter*, a respiration regulating center, similar to that in the corpora bigemina of the frog: electrical stimulation of this center causes accelerated inspirations finally passing into tetanic fixation of the chest in an inspiratory condition, and correspondingly diminishes or altogether inhibits expiration."

The paper of Dr. I. Edmondson Atkinson, on the botanical relations of *Tricophyton tonsurans*, details some very careful experiments in cell-culture made in order to determine whether excessive polymorphism existed among these lower fungi.

Dr. W. K. Brooks closes Part I with a memoir entitled "Preliminary Observations upon the Development of the Marine Prosobranchiate Gasteropods." For material the author studied two common marine snails from the first segmentation of the egg to a stage when it emerges with its full class characters. Among other things he shows that, while there is no stage that can be considered as a specialized gastrula, there are presented at different periods of its development all the phases in the formation of a gastrula; and also that, while the gastrula stage has disappeared, the gastrula form persists.

Part II commences with a memoir by Professor Martin and Edward M. Hartwell, on the respiratory function of the internal intercostal muscles. The authors show how conflicting are the opinions regarding the particular mechanical work done by these muscles; and how impracticable it is to decide by a simple mechanical study as to whether these muscles are rib-elevators or rib-depressors. Dogs and cats were used in their experiments, which show that the muscles in question are expiratory in their function throughout their whole extent.

The next paper, by Isaac Ott, M. D., entitled "Observations on the Physiology of the Spinal Cord," is an account of the author's investigations of the secretory functions, vaso-dilator centers, rhythmical functions, genito-urinary functions, and path of secretory and inhibitory fibers of the cord.

On the "Effect of Two Succeeding Stimuli upon Muscular Contraction," by Henry Sewell, Esq., is a paper which affords an excellent example of how minute and exact experiments should be conducted. Among other interesting facts it is shown that a "given maximal stimulus stirs up the untired muscle to a more powerful contraction when it has been preceded by the excitement ordinarily producing contraction."

In the "So-called Heat Dyspnœa," by Christian Sihler, M. D., is an attempt to get at the causes of the increased respirations in a dog, when it is subjected to a temperature warmer than its own body. Finding previous experiments inconclusive, the author not only repeats those of Goldstein, but details a number of new ones. His conclusions are: 1. That Goldstein's experiment with the tube is inconclusive; 2. The increased respiration following exposure of the animal is due to two causes, skin stimulation and warmed blood; 3. Of these, skin stimulation is the more powerful; 4. Apnœa can be produced in heated animals,

if skin stimuli be cut off; 5. The direct action on the respiratory centers of the hotter blood of the heated animal is probably not, or not only, due to its temperature but to its greater venosity.

Dr. W. K. Brooks has an exhaustive paper entitled "Observations upon the Early Stages in the Development of the Fresh-Water Pulmonates," in which he discusses the works of Lankester, Fol, Rabl, Jhering, and others. The plates accompanying his paper are models of clearness.

S. F. Clarke follows with an interesting illustrated paper on "The Development of Amblystoma," which closes the number.

Part III, devoted to the work of the Chesapeake Zoölogical Laboratory during the session of 1878, begins with an account by Professor W. K. Brooks of the organization of the school, its location at Fort Wool, and the methods of study adopted. This is followed by lists of the plants and animals observed at Fort Wool—the former by Mr. N. B. Webster and the latter by Mr. P. R. Uhler. The next paper, by Dr. Brooks, is on the development of Lingula and the systematic position of the Brachiopoda. He succeeded in getting the free-swimming larva of Lingula at a stage similar to the one described by Professor McCready many years ago, and carried it through to the early stage of the adult form. It is useless to attempt to do justice to this valuable contribution without the plates which accompany it.

The other papers in this part are "On the Larval Stage of Squilla," by Dr. Brooks, and the "Description of Lucifer Typus," by Walter Faxon.

Part IV contains a paper of great scientific and economic value, on the development of the oyster, by Dr. Brooks. German and French authorities had stated that eggs of the oyster were fertilized within the body of the parent, and were carried by them until they had reached an advanced stage of development, when, provided with shells of their own, they were discharged, and swam freely in the water until they became attached. Misled by these statements, Dr. Brooks had failed the season before in securing any results. On the 15th of May he commenced operations by opening oysters every day throughout the breeding-season. His success in artificially fecundating the egg was remarkable. Millions of eggs were fecundated with but little trouble. He traced their developmental history from the segmentation of the egg to those stages already described by European naturalists. He found the female oyster in various conditions: some in which the ovaries were largely distended, and the eggs fairly oozing from the oviducts; others in which the ovaries were half filled, and others still wherein the ovaries were quite empty, and in no case did he find a single fertilized egg in the ovary. Dr. Brooks emphatically says that, so far as the oyster of Chesapeake Bay is concerned, "the eggs are fertilized outside the body of the parent, and that, during the period which the young European oyster passes inside the mantle cavity of its parent, the young of our oyster swims at large in the open ocean." A very clear description is given of the anatomy of the oyster, as well as some practical points in regard to their artificial fecundation. A careful estimate shows that an average-sized female oyster contains about nine million eggs; an unusually large oyster may contain as many as sixty million eggs.

Dr. Brooks's investigations have a very practical bearing on the question as to the final exhaustion of the natural oyster-beds on our coast by unlimited dredging.

One would naturally think that with such remarkable fecundity the question of extermination need be hardly entertained, but the eggs after fertilization, if left unprotected, meet at every moment of their existence enemies who devour them, and, when at a later stage they rise on the water and form a film on the surface, fishes devour them by millions. Dr. Brooks has shown that if the egg is not immediately fertilized it soon perishes, and of course in its natural home the chances of its fertilization are infinitely less than in the artificial method actually tried.

In a recent paper by Dr. Mobius a long table is given showing the number of oysters taken yearly from the Bay of Cancale, on the coast of Norway, during the last hundred years. Dr. Brooks reproduces this table, to show that unlimited dredging has greatly reduced the production.

Without detailing the process here, Dr.

Mobius estimates that each oyster born has $\frac{1}{1145000}$ of a chance of reaching maturity. In the case of the American oyster, the number of eggs being very much greater, each one's chance of survival is very much less.

He shows, too, how extremely circumscribed are the beds upon which the oyster thrives, and that it is a mistake to suppose that the oysters are promiscuously scattered on the shores of the bay. They can only flourish on certain grounds, though the young are widely scattered through these waters, as the partial development of individuals everywhere attests. This Part closes with another article by the same author, on "The Acquisition and Loss of a Food-Yolk in Molluscan Eggs."

Incomplete as our account of these papers must necessarily be, enough has been said to show that they are the records of a large amount of original thoroughgoing scientific research, the results of which will become increasingly valuable as they are more generally known. But of the manner in which these records have been brought together we can not speak so favorably. Several of the memoirs were first published elsewhere, and in their collection the original paging and numbering of the plates have been allowed to stand. The lack of uniformity thus caused is very confusing, and, as the high character of the work will make it widely sought for purposes of reference, much future trouble may be expected from this defect in its make-up.

The Irish Land Question. By Henry George. New York: D. Appleton & Co. 1881. Pp. 85. Price, 25 cents.

In this essay Mr. George applies to the Irish land question the doctrine maintained in his now well-known work "Progress and Poverty," and appeals to the Land Leagues to openly espouse the reform he advocates. He insists that there is nothing special in Irish distress; that it is not due to English oppression, but that it is the direct result of a land system that prevails in every civilized country. He points out that so far from Irish land tenure being worse than that of other countries, it is even more favorable to the tenant, and that, as a matter of fact, the land of Ireland is under-rented. He argues forcibly against the various schemes for a greater subdivision of the land, showing that these can benefit the tenant but to a limited extent, while to agricultural laborers and artisans they can bring no relief whatever. He therefore urges the reform he advocates, as a final solution, not only of the land question in Ireland, but in every other country, and feels confident that, if the Irish trouble could be adjusted on this basis, the extension of the system to other countries would be but a matter of time. At the very outset of any proposal for the state to resume the ownership of the land, the question of compensation to landholders must be met. In his previous work Mr. George has argued that the landholders ought to receive no compensation, an opinion for which he has been somewhat sharply criticised. In the present essay he again takes up the question and argues it at greater length. He denies that the case is one to which the statute of limitation can be made to apply, and claims that the landholder is not deprived of what is rightfully his, but simply estopped from further enjoying the fruits of the labor of others.

The remainder of the essay is devoted to an insistence upon the importance of the right solution of the land question and the benefits that would follow the one the author proposes.

Medical Hints on the Production and Management of the Singing Voice. By Lennox Browne, F. R. C. S., Edinburgh. Eighth edition, revised, enlarged, and illustrated. New York: M. L. Holbrook & Co. Paper. Pp. 77. Price, 25 cents.

This essay, which was first given in the form of a paper before a Musical Association, is intended to furnish the information most necessary and desirable for singers to possess, in a practical, untechnical shape. It considers—1. The laws of musical sound bearing on the question discussed; 2. The organs of the human voice regarded as parts of a musical instrument, and their various functions as such; 3. The management of those parts under control of the vocalist which may perfect the voice; 4. The defects occasioned by mismanagement; and, 5. Directions on the hygiene and medical and dietetic management of the voice. The last topic is treated in full.

Report of the Commissioner of Education for 1878. Washington: Government Printing-Office. 1880. Pp. 730.

The office of the Commissioner of Education is a peculiar one. It has no authority, but depends wholly upon voluntary assistance for the collection of the information which it undertakes to digest and diffuse, and its recommendations, if it makes any, can pass only for what they are intrinsically worth. Its function, as the Commissioner well remarks, is that of "'a national clearing-house' of educational information, where what has been done is carefully recorded, and that which indicates the good or bad may be selected." That its work is more appreciated every year is shown by the steadily increasing number of its correspondents at home, who numbered 7,135 in 1878, and the extension of its connections abroad. The present volume contains full information, with all the details, on the condition of public and private education in the United States, arranged by States, and according to the grade and character of the institutions, and one of the most satisfactory accounts of the condition of education in foreign countries that the Commissioner has yet been able to present.

Photometric Researches. By William H. Pickering. Extracted from the Proceedings of the American Academy of Arts and Sciences. Cambridge, Massachusetts: University Press. 1881.

Very little is known with accuracy of any terrestrial high temperature, while estimations of that of the sun vary between the extreme limits of several million and two thousand degrees. In the researches to which this paper is devoted, Professor Pickering has endeavored to determine some of these temperatures by means of the amount of violet rays given off, these being the rays most abundant at the highest temperature. The exact relation between these factors is unknown, but, by assuming one which his experiments led him to regard as probable, Professor Pickering has been able to make out a table which does not differ widely from the most reliable determinations heretofore made. The lights of a candle, gas-flame, lime, magnesium, the electric arc, moonlight, and sunlight were each examined by means of a spectroscope and photometer, and the relative brilliancy of the red, yellow, green, and violet rays determined. The standard used was an Argand gas-flame with a small screen interposed, so that the light yielded was just ·67 candle-power, and a candle was found to be wholly unsatisfactory for the purpose. The relative intensities of these portions of the spectrum were in each of the lights as follows, that of the yellow rays being taken at 100: Candle, 73, 100, 104, 134; gas, 74, 100, 103, 125; lime, 59, 100, 113, 285; magnesium, 50, 100, 223, 1,129; electric light, 61, 100, 121, 735; moonlight, 87, 100, 155, 363; sunlight, 45, 100, 250, 2,971. The great preponderance of the violet rays in burning magnesium over those of any other artificial light clearly indicates a higher temperature, while by the same test that of the sun is much greater. The temperatures for all the lights measured are: Candle and gas, 1,200° C.; lime, 2,000° C., about that of melted platinum; electric arc, 3,500° C.; magnesium, 4,900° C.; sun, 22,000° C. This method of obtaining temperatures gives promise of being of great value, for, as pointed out by Professor Pickering, if the relation between increase of temperature and increase of violet rays were accurately determined, we could very readily determine the temperature of the heavenly bodies.

Studies of the Food of Birds, Insects, and Fishes, made at the Illinois State Laboratory of Natural History. Normal, Ill. Paper. Pp. 160.

The State Legislature of Illinois recently authorized an investigation of the food of the birds of the State, with especial reference to agriculture and horticulture, and a similar investigation of the food of fishes, with especial reference to fish-culture. The papers in this collection are the first results of the work. As the investigation proceeded it was found that, to be full, it must include a consideration of parts of the general subject of the reactions between groups of organisms and their surroundings, organic and inorganic. With this view the special papers are preceded by a more general one on "Some Interactions of Organisms." Papers are also given on "Insectivorous Coleoptera," and on "The Food of Predaceous Beetles."

United States Commission of Fish and Fisheries. Part VI. Report of the Commissioner for 1878. A. Inquiry into the Decrease of Food-Fishes. B. The Propagation of Food-Fishes in the Waters of the United States. Washington: Government Printing-Office. 1880. Pp. 988.

The present report brings down the history of the work of the commission to the end of 1878, and a part of it, especially that connected with the propagation of salmon, to the date of the actual planting and disposition of the young fish in 1879. The scale of operations was increased during the year, in correspondence with the increased appropriations made by Congress, without bringing any material addition to the expense of the management. The history of the operations includes the record of the progress of the planting of different varieties of salmon, of which we may mention the planting of California salmon in the Southern rivers, and of the measures to promote the increase of the white-fish, shad, herring, carp, and cod. The attempt to introduce the sole met with a second failure. An experiment in the artificial propagation of the sponge of commerce, by planting cuttings of live sponges, was successful, and gave much encouragement. The supplemental papers are of great interest, and constitute of themselves a respectable library of ichthyological literature. They embrace numerous articles, by American, Scandinavian, and German writers, on subjects connected with fishery expositions, the sea-fisheries, deep-sea research, the natural history of marine animals, and essays general, special, and practical, on the propagation of the different kinds of food-fishes.

Natural Theology. By John Bascom. New York: G. P. Putnam's Sons. 1880. Pp. 302. Price, $1.50.

Dr. Bascom, who is widely and favorably known as one of the strongest thinkers within theological lines, has here recast the theistic argument, and has endeavored to present it in a form which shall meet the changed conditions and enlarged knowledge of to-day. The argument is conducted in excellent temper, and is in many respects a strong and able presentation of what the intuitive philosophy has to offer upon this fundamental question. His attitude toward current scientific doctrine and the spirit in which he approaches his work are indicated in the following quotation from the preface: "The opposition has changed front, and so renders a corresponding change necessary on the part of the defense. This shifting of the conflict has attended on a great increase of knowledge, and new views of the methods of development in the physical world. We wish to recognize most fully the value of these attainments, and to see clearly their relation to theism. We are quite prepared to accept evolution — the present intellectual solvent of physical problems—in all the facts it offers, while we are still at liberty to give those facts the interpretation which is most in keeping with the two kingdoms, physical and spiritual, which make up the universe in its outer form and inner force. It is exactly here that we hope to add something to the work of our predecessors—1. In a more complete recognition of all the results of scientific inquiry; and, 2. In pointing out the relation of these facts to an intellectual exposition of the universe." Dr. Bascom, in his discussion of the nature of the Deity, reaches the conclusion that a sufficient, positive, and consistent idea of his nature is obtainable; and he then, after stating the kind of proof necessary, carries his search for it through the organic world and into the "rational kingdom," closing his argument with a consideration of the goodness of God and the bearing the evidence of this has upon his existence. The concluding chapter of the work is devoted to a discussion of immortality, its relation to natural theology, and the proofs of it from the constitution of man, and the character of the Deity.

Drainage for Health; or, Easy Lessons in Sanitary Science. By Joseph Wilson, M. D., Medical Director, United States Navy. Philadelphia: Presley Blakiston. 1881. Pp. 68. Price, $1.

The author attempts, in this work, to present the subject, briefly and correctly, so far as he goes, in simple style and language, and in so familiar a manner as to make easy reading. He first discusses the subject of land-drainage on farms and in country districts; next the drainage of cities and town-houses, closets, and plumbing.

The Care and Culture of Children. A Practical Treatise for the Use of Parents. By Thomas S. Sozinskey, M. D., Ph. D., author of the "Culture of Beauty," etc. Philadelphia: H. C. Watts & Co. 1880. Pp. 484. Price, $2.50.

The author's object in this work is to give such information and advice as will enable parents to perform intelligently their duty to their children in matters of physical and mental training, in health and sickness. The first part relates to the care of children, and includes chapters on the conditions of health, diet, clothing, cleanliness, exercise, etc., the prevention of disease, and treatment in sickness of whatever character. In the second part, physical and intellectual culture is discussed, with faithful attention to details and an evident desire to cover the whole subject. The style is in many places brief and pointed, in others diffuse.

Baldwin Locomotive Works. Illustrated Catalogue. Second edition. Philadelpia: J. B. Lippincott. 1881. Pp. 152. Price, $5.

This, while being a very elegant trade catalogue, is also something more, by reason of the summary of the progress of locomotive construction in this country which it contains. The account is in the form of a history of the works, but, as Mr. Baldwin was one of the first and most successful locomotive-builders, the history of his efforts is largely that of the continuous improvements which have transformed the locomotive of 1830 into that of to-day. In the catalogue proper the various types of locomotives now made at the works are illustrated by photographs and scale drawings.

"Change" as a Mental Restorative. By Joseph Mortimer-Granville. London: David Bogue. 1880. Pp. 32.

Change—of place, surroundings, or occupation—is, the author believes, too often prescribed without sufficient discrimination, so that sometimes the patient's situation is not improved, or may even be made worse, by the new exercise or in the new place. The present essay is a study of the manner in which change may operate beneficially, of the kind of change that is good, and of the principles by which the prescription of it should be guided.

Pueblo Pottery. By F. W. Putnam. From the "American Art Review" for February, 1881. Pp. 4, with colored Plate.

In this paper are described a number of specimens of pottery of the Pueblos of New Mexico, with peculiar decorations, some of which provoke comparisons with the ornamentation of the Cyprian potteries. The largest vessel, from Zuñi, is marked with considerable taste, and displays striking figures of deer in black, and a conventionalized shrub in red. A water-bottle from San Ildefonso is rudely fashioned in the shape of a bird, and is decorated, like some of the Cyprian pottery, with figures of birds painted in black upon a white ground. A third vessel shows a more common ornamentation of Pueblo pottery. A comparison of modern specimens with ancient shows that the art has deteriorated. The ornamentation in both kinds is confined to figures expressed in color. No specimen of incised work is known. The representation of natural forms appears to be of modern introduction.

Adam Smith. By J. A. Farrer. New York: G. P. Putnam's Sons. 1881. Pp. 201. Price, $1.25.

This is the opening volume of a series to be devoted to an exposition of the chief contributions made to philosophy by English thinkers. In explanation of the purpose of the project, the editor, Professor Iwan Müller, says in the preface: "We seek to lay before the reader what each English philosopher thought and wrote about the problems with which he dealt. . . . Criticism will be suggested rather than indulged in, and these volumes will be expositions rather than reviews. . . . It is hoped that the series, when complete, will supply a comprehensive history of English philosophy." Professor H. Sidgwick will contribute a volume under the title of "Introduction to the Study of Philosophy," and arrangements have already been made for the early appearance of volumes upon Bacon, Berkeley, Hamilton, J. S. Mill, Mansel, Bentham, Austin, Shaftesbury and Hutcheson, Hobbes, Hartley and James Mill. These will be followed by others upon Locke, Hume, Paley, Reid, and later philosophic writers. The design of the series is excellent, and, if all the contributors do their work as well

as Mr. Farrer has done his, it will be a valuable one. The present volume is devoted to an exposition of the "Theory of the Moral Sentiments," in which the great economist endeavors to find for morals a secure foundation in the sympathetic nature of man. The work was in its time a notable one, and remains one of the most valuable contributions of English thought to the subject. Mr. Farrer writes clearly and appreciatively, and has invested his subject with an interest that will make the book attractive to a large number of readers. The exposition closes with an examination of some of the objections urged by writers at the time of the publication of the "Theory," and is preceded by a brief biographical sketch of Smith.

The Devonian Insects of New Brunswick. By Samuel H. Scudder. Boston: Boston Society of Natural History. 1880. Pp. 41, with Plate.

Careful descriptions are given in this essay of six specimens of broken wings which were discovered in 1862 by Professor C. F. Hartt, in the Devonian shales of Carleton, near St. John, New Brunswick, and are now preserved in the museums of the Natural History Society of St. John and of the Boston Society of Natural History. The descriptions and the author's conclusions are supplemented by a review of the character and age of the formation in which the remains were found, by Principal Dawson, in which the evidence that it is Devonian is carefully collated. The wings are all of *Neuroptera*, and of species to which are ascribed special relations with the modern May-flies. From his detailed examinations, Mr. Scudder reaches the conclusion that nothing appears to interfere with the view he has formerly expressed, that the general type of wing-structure has remained unaltered from the earliest times; that the fossils are nearly all of synthetic types of a comparatively narrow range, being about equally divided in structural features between *Neuroptera* proper and pseudo-*Neuroptera;* that they bear marks of affinity to the Carboniferous *Palæodictyoptera*, while they are often of more complicated structure than most of them, but with this exception bear little special relation to Carboniferous forms; that they were of great size, had membranous wings, and were probably aquatic in early life; that some of them were plainly precursors of existing forms, while others seem to have left no trace; that they show a remarkable variety of structure, indicating an abundance of insect-life at that epoch; that they differ remarkably from all other known types, ancient or modern, and some of them appear to be even more complicated than their nearest living allies; that we appear to be, so far as either greater unity or simplicity of structure is concerned, no nearer the beginning of things in the Devonian epoch than in the Carboniferous; and that "while there are some forms which, to some degree, bear out expectations based on the general derivative hypothesis of structural development, there are quite as many which are altogether unexpected, and can not be explained on that theory, without involving suppositions for which no facts can at present be adduced." We observe that some of the views of the author are questioned by other naturalists.

Orange Insects: A Treatise on the Injurious and Beneficial Insects found on the Orange-Trees of Florida. By William H. Ashmead. Jacksonville, Florida: Ashmead Brothers. Paper. Pp. 78.

The author has been engaged in special studies of the insects of the orange since 1876, and publishes this volume in answer to numerous inquiries for information respecting them from cultivators. He gives systematic descriptions of numerous species, with illustrations of the most of them, and notes on the character of their relations—whether beneficial or injurious—to the trees.

Circulars of Information of the Bureau of Education: No. 4, Rural School Architecture. With Illustrations. Pp. 106. No. 5, English Rural Schools. Pp. 26. Washington: Government Printing-Office. 1880.

The former work has been prepared by Mr. T. M. Clark, an architect of Boston, with the design of giving principles and directions suggestive of the plans best to be adopted under a variety of circumstances rather than of laying down rules to be inconsiderately followed. It is intended to cover the whole subject of school architecture, with especial attention to the proper

heating and efficient ventilation of the buildings. It begins with the consideration of the site and the digging of the well, and closes with the elevations and finishings of the schoolhouses. An article on log schoolhouses is added. Circular No. 5 is a statement of the working of the English education act of 1870 in districts outside of cities, prepared for the department, by Mr. Henry W. Hulbert.

Electric Lighting by Incandescence. By W. E. Sawyer. New York: D. Van Nostrand. 1881. Pp. 189. Price, $2.50.

In these chapters Mr. Sawyer has given a *résumé* of the present condition of electric lighting by incandescence, describing the chief apparatus that has been so far devised. He begins his exposition with a consideration of the various electric generators, as these necessarily are at the foundation of any system of electric lighting. Of these the two important classes are those of the Gramme type, in which he includes those of Maxim and Brush; and those of the new Siemens type, in which he places his own and Edison's. The Wilde, De Meritens, and Lontin machines are also described, the first being characterized as the "germ of a perfect generator," in that in it the intensity of the magnetic field is uninfluenced by the resistance of the external circuit, and a larger part of the entire current can therefore be used than in accumulative machines. The review of incandescent lamps includes those of Starr and King, Lodyguine, Konn and Kosloff, Bouliguine, Fontaine, Farmer, Sawyer, Edison, and Maxim, in which the carbon is protected from the atmosphere, and those of Reynier and Werdermann, in which it burns in the air. Of the former, only the last three are regarded as practicable lamps, and of these the Maxim is considered as, in all essential particulars, a duplication of that of Edison. With regard to the duration of the carbon, Mr. Sawyer holds that the hope of making it permanent is chimerical, as no material will stand the strain to which an incandescent conductor is subjected, and that the part of wisdom, therefore, is to provide for its renewal. In treating of the division of the current, four systems are considered—the series, the multiple, the multiple-series, and the series-multiple system. In the first, the lamps are strung one after the other upon one wire; in the second, each lamp is hung on a branch between two parallel wires; in the third, several lamps are placed upon a branch; and, in the last, groups or bunches of lamps are strung upon one wire. For a large number of lamps, Mr. Sawyer considers the first arrangement impracticable, and the last, which he has adopted, the most desirable. Regarding the cost of incandescent lighting, the conclusion is reached that it is not more than one seventh of that of gas for equal light, while the cost of plant, repairs, etc., will be much less. As to the future of incandescent lighting, and its relations to other forms of illumination, Mr. Sawyer expresses himself as follows: "The application of electricity to public and private illumination is a realization of the near future no longer to be questioned. It is not probable, however, that electricity will ever entirely supersede gas; indeed, it does not appear that illuminating gas has materially affected the consumption of illuminating oils. There is room, and will doubtless continue to be room, for all methods of artificial lighting, and it is not likely that, for many years to come, we shall witness anything more than the extensive use of electricity—public buildings and private residences, streets, and squares better illuminated than at present, and the new form of light keeping pace with the progress of older and well-tried institutions."

The Cause of Color among Races and the Evolution of Physical Beauty. By William Sharpe, D. D. New edition, revised and enlarged. New York: G. P. Putnam's Sons. 1881. Pp. 36. Price, 75 cents.

The author's views are partly based on observations made among the different races of India. He supposes that lighter-colored peoples are developed from darker colored ones by a process of evolution which corresponds with the advance of civilization, and is promoted by the increasing habit of wearing clothing. The qualities which give a dark color to the skin are those which are necessary to preserve it against the inclemency of the elements. As clothing becomes more general, fuller, and more regularly worn, they become less important for protection, and are finally nearly obliterated.

The Boy Engineers: What they did and how they did it. A Book for Boys. By Reverend J. Lukin. New York: G. P. Putnam's Sons. Pp. 344. Price, $1.75.

This useful book is another result of the author's intelligent interest in the mechanical education of boys. He has contributed various volumes to this object, dealing with the subject in different ways, but all aiming at a practical familiarity with mechanical operations, and successfully to combine working and thinking. The "Boy Engineers" begins with the construction of a plain and simple workshop which a couple of boys extemporize, and then it follows them through a course of self-culture in mechanics. They first get up a grindstone for their purposes and learn to sharpen tools. Then they make a lathe and go on with the preparation of various workshop appliances. A wooden clock was next constructed, and then they proceeded to make an organ. Carpentry and the problem of house-construction were next attacked, and after that they devoted themselves to all sorts of mechanical contrivances and operations such as might constitute a fitting preparation for the thorough study of engineering. The book is well adapted to interest enterprising boys, and is full of information that will be useful to many grown men.

American Sanitary Engineering. By Edward S. Philbrick, C. E. New York: "The Sanitary Engineer." 1881. Pp. 129.

In the dozen lectures comprising this volume Mr. Philbrick has made a very excellent statement of the main conditions to be observed in sanitary construction, and presented the chief considerations which show the need and importance of such work. In his introductory lecture he points out the great progress that has been made toward a higher standard of cleanliness, and the need of a continuance in the same direction to meet the conditions of modern life. The first of his two lectures upon ventilation he devotes to a very full statement of the conditions which affect the purity of the air, the vitiation of it produced by respiration, lights and fires, the proper amounts of watery vapor for different temperatures, the influence of the materials of walls in allowing an air circulation, and the position of the rooms with regard to exposure to the external air, the results of the most trustworthy experiments being given on these points. In the second lecture on this subject the various ways of moving air are considered; and in this connection the different methods of heating are treated, their several advantages as determined by experience being indicated. In speaking of gaslight he points out what has been frequently pointed out before, but has been very little heeded, that, by the simple device of placing a duct above a chandelier, air vitiation by gas can be entirely obviated. This construction also secures excellent ventilation. The chapters upon drainage and sewage include a consideration of the different systems of sewage disposal, the proper construction of sewers, the means of ventilating them, and brief descriptions of closets, traps, and the various appliances connected with the water-carriage system, which the author regards as the only practicable system for cities. The subject throughout is considered with reference to American climatic conditions.

The Food of Fishes. By S. A. Forbes. Bulletins of the Illinois State Laboratory of Natural History, November, 1880. Pp. 62.

The author assumes that, by reason of its isolation from the land and from other water systems, a far more complete and independent equilibrium of organic life and activity is found in a single body of water than in any equal body of land. Hence each form of life must be studied with reference to its relation to other forms and to its whole environment, of which its food relations are one of the most important features. A number of definite general correspondences between structure and food are indicated by the study of certain structural conditions about the mouth, throat, and gills of fish, of which it is hoped a full enough knowledge may be reached to enable the character of the food of an unknown species to be determined by a mere inspection of the fish itself. The present paper is a contribution to the study in these relations of the *Acanthopteri*.

Extracts from Chordal's Letters. New York: "American Machinist" Publishing Co. Pp. 320. Price, $1.50.

This is a collection of letters contributed during the past two years to the "American Machinist," and published under the above title. They treat of all sorts of topics connected with the work and management of a machine-shop in a bright, attractive style, and are very interesting reading to others than machinists. To the young mechanic the book is of especial value for its constant insistence upon the necessity of good work if a man would rise, and its scorn of the careless and shiftless workman. The author does not stop to moralize, but this thesis is presented at every turn in the many examples and illustrations of shop-work given, and in a way to enable the dullest reader to see its bearing.

Tide-Tables for the Atlantic Coast of the United States for the Year 1881. The same for the Pacific Coast. Washington: Government Printing-Office. Pp. 129 and 65. Price, 25 cents each.

The tables give for every day of the year the approximate predicted times and heights of the tides at the principal ports on either coast, including fifteen ports on the Atlantic and four ports on the Pacific coast. For intermediate ports, tables of tidal constants are appended, from which the times and heights of the tides may be computed for those places by applying the corrections which are designated to the figures assigned to the principal ports with which they are grouped.

Report on the Marine Isopoda of New England and Adjacent Waters. By Oscar Harger. (From the Report of the United States Commissioner of Fish and Fisheries, 1878.) Paper, pp. 168.

The report includes descriptions of the species of *Isopoda* which are at present known to inhabit the coast of New England and the adjacent regions, as far as New Jersey on the south and Nova Scotia on the north. Besides the special labors of the Fish Commission, the collections of Professors Verrill and Smith, of Yale College, and others, have been used as aids in the study. The descriptions are full, and nearly all the species are figured in more or less of detail. The family, named from all the legs being thoracic and generally similar, is represented on land by the common "sow-bugs," "hill-bugs," and wood-lice.

A Syllabus of Anglo-Saxon Literature. By J. M. Hart. Adapted from Bernhard Ten Brink's "Geschichte der englischen Litteratur." Cincinnati: Robert Clarke & Co. 1881. Pp. 69.

This work furnishes a history and analysis of Anglo-Saxon literature in its whole field and in the view of its various relations, with commentaries calling attention to its leading characteristics, and pointing out the peculiarities of particular authors and works.

Second Biennial Report of the Superintendent of Public Instruction of the State of Colorado. Denver: Tribune Publishing Company. 1879–1880. Pp. 134.

This pamphlet contains, in addition to the Superintendent's review of his work for two years, a synopsis of the public-school system of Colorado, the reports of the county superintendents and of the University of Colorado, and the addresses delivered at the annual meeting of the State Teachers' Association. Of 35,566 children of school-age in the State, 22,119 were enrolled in the schools, and the average attendance was 12,618. The expenditure *per capita* of school population was $11.07, and the expenditure *per capita* of average attendance was $31.38. The university was attended by 121 students. The addresses before the Teachers' Association include one on "Influence," by the President; a criticism of classical education, by Mr. David Boyd; and a plea for the higher education of women, by Mr. F. E. Smith.

Papilio: Devoted to Lepidoptera exclusively. Organ of the New York Entomological Club. New York: Henry Edwards, 185 East 116th Street. January, February, and March numbers. Pp. 12, each. Price, $2.00 for ten numbers.

This magazine is published monthly, except in the two "summer vacation" months. In connection with its special subject it will embrace within the scope of its articles notes on the transformations and diseases of the *Lepidoptera*, their use and detriment

to the human race, the parasites which prey upon them and assist in keeping them in check, descriptions of new species, etc. The three numbers contain an article on the "Importance of Entomological Studies," a biographical sketch of M. Achille Guenée, and numerous descriptions of species, with a chromolith illustration of *Edwardsia brillians.*

PUBLICATIONS RECEIVED.

How we feed the Baby. By C. E. Page, M. D. New York: Fowler & Wells. 1881. Pp. 144. Price, 75 cents.

Unscientific Materialism. By S. H. Wilder. Reprint from "The International Review." New York. 1881. Pp. 16.

Annual Address of the President of the Middletown Scientific Association. By Rev. Frederick Gardiner, D. D. Middletown, Connecticut. 1881. Pp. 19.

The Endowment of Scientific Research. By Professor George Davidson, Ph. D. From an Address before the California Academy of Sciences. Pp. 8.

Our Trees in Winter. By John Robinson. From the "Bulletin" of the Essex (Massachusetts) Institute. Pp. 16.

Department of Science and Arts, Ohio Mechanics' Institute. Cincinnati. 1881. Pp. 12.

"The Coöperator." A Monthly Journal devoted to the Promotion of Coöperative Action in all its Forms. Vol. I, No. 1. New York: A. R. Foote. 1881. Pp. 16. Price, $1 a year.

Essay upon Ensilage. By J. M. Bailey. Pp. 10.

Report of the Director of the Detroit Observatory of the University of Michigan, from October 1, 1879, to January 1, 1881. Ann Arbor, Michigan. 1881. Pp. 20.

Industrial Conciliation and Arbitration. By Joseph D. Weeks, A. M. Boston: Rand & Avery. 1881. Pp. 73.

Preliminary List of the North American Species of Agrotis. By A. R. Grote. Washington. 1881. Pp. 16.

Climatology of Florida. By C. J. Kenworthy, M. D. Savannah, Georgia. 1881. Pp. 70.

Railroads and Telegraphs: Who shall control them? By F. H. Giddings. Springfield, Massachusetts. 1881. Pp. 12.

President's Inaugural Address before the American Society of Mechanical Engineers. By R. H. Thurston. Pp. 16.

The Gradual Dispersion of Certain Mollusks in New England. By Edward S. Morse. Pp. 6.

Annual Report on the Surveys of Northern and Northwestern Lakes, in Charge of C. B. Comstock. Washington. 1880. Pp. 94.

Quarterly Report of the Chief of the Bureau of Statistics, Treasury Department, for the Three Months ended September 30, 1880. Washington: Government Printing-Office. 1881. Pp. 133.

Annual Report of the Ontario Institution for the Education of the Blind. Toronto: C. Blackett Robinson. 1881. Pp. 28.

Simple Apparatus for determining Specific Heats of Solids and Liquids with Small Quantities of Material. By J. W. Mallet, F. R. S. From "The American Chemical Journal." Pp. 14.

Failure of Vaccination. By Carl Spinzig, M. D. St. Louis. 1881. Pp. 15.

The Rocky Mountain Locust. By Charles V. Riley, Ph. D. Pp. 50. With Maps.

A New Order of Extinct Jurassic Reptiles. Discovery of a Fossil Bird in the Jurassic of Wyoming; and Note on American Pterodactyls. By O. C. Marsh. Reprint from "The American Journal of Science," April, 1881.

Annual Report of the Board of Health of the State of Louisiana for 1880. New Orleans: J. S. Rivers. 1881. Pp. 354.

Annual Report of the Superintendent of the Yellowstone National Park for 1880. Washington: Government Printing-Office. 1881. Pp. 64.

On Quebracho-Bark. By Dr. Adolph Hansen. Translated from the German. Pp. 13.

Meteorological Researches. By William Ferrell. On Cyclones, Tornadoes, and Waterspouts. Being Part II of Appendix No. 10, of Report of the Superintendent of the United States Coast and Geodetic Survey. Washington: Government Printing-Office. 1880. Pp. 95. With Plates.

Journal of the Academy of Natural Sciences of Philadelphia. Vol. viii, second series. Philadelphia. 1874–1881. Pp. 118. With Plates.

Practical Phonics. By E. V. De Graff, A. M. Pp. 108. Price, 75 cents. Regent Schools of the State of New York. By C. W. Bardeen. Pp. 24. Price, 25 cents. Suggestions for teaching Fractions. By W. W. Davis. Pp. 43. Price, 25 cents. New York Examination Questions. Pp. 111. Price, 25 cents. Hints on Orthoëpy. By C. T. Pooler, A. M. Pp. 15. Price, 10 cents. Handbooks for Young Teachers. No. 1, First Steps. By Henry B. Buckham, A. M. Pp. 152. Price, 75 cents. Syracuse: C. W. Bardeen. 1881.

The Telescope. By Thomas Nolan, B. S. New York: D. Van Nostrand. 1881. Pp. 75. Price, 50 cents.

History of the Free-Trade Movement in England. By Augustus Mongredieu. New York: G. P. Putnam's Sons. 1881. Pp. 184. Price, 50 cents.

Victor Hugo: His Life and Work. From the French of Alfred Barbou. By Frances A. Shaw. Chicago: S. C. Griggs & Co. 1881. Pp. 207. Price, $1.

Our Native Ferns. By Lucien M. Underwood, Ph. D. Bloomington, Illinois. 1881. Pp. 116. Price, $1.

Sir William Hamilton By W. H. S. Monck, M. A. New York: G. P. Putnam's Sons. 1881. Pp. 192. Price, $1.25.

The Science of Mind By John Bascom. New York: G. P. Putnam's Sons. 1881. Pp. 456. Price, $2.

History of the Christian Religion to the Year Two Hundred. By Charles B. Waite, A. M. Second edition. Chicago: C. V. Waite & Co. 1881. Pp. 454. Price, $2.50.

POPULAR MISCELLANY.

Health and Material Prosperity.—The report of the Board of Health of New Haven contains, in a letter from Professor Brewer, President of the Board, to the Common Council of the city, a convincing statement of the closeness of the relation between a good sanitary condition and the material prosperity and wealth of a city or community. An individual, to prosper by his labor, must be reasonably well; the same is equally true of a community or state. In the intense competition of mod-

ern times, no sickly community can be prosperous. It may be intelligent, and moral, and industrious, but it must be poor. Hence it is a duty, imposed not only by the claim of the individual on the community, but also by the vital interest of the community itself, to protect every person in it against those diseases and dangers whose power for evil has grown along with our civilization. The wonderfully rapid accumulation of wealth, far surpassing anything ever witnessed in the past, which is one of the characteristics of modern times, is not due to improvements in machinery, to applications of science, to the spread of education, the decrease of wars, or the more extended production of precious metals, though all these have contributed their part, so much as to the better average health of civilized countries and the longer average term of life which is now secured to workingmen. Even now, a single pestilence like those with which Savannah and Memphis have recently been afflicted, may set the most prosperous city back many years. New Haven has had but one visitation of yellow fever, but it took the city eight or ten years to recover from the visible effects of it, and a permanent loss of "what might have been" was suffered at a critical period in the commercial development of the city, the value of which can never be ascertained or guessed. The sanitary work, which is of such importance in this aspect of civic life, is often overlooked, because of its unobtrusive character; and it is never more efficient than when it is least obtrusive. In the ordinary pursuits of business, the clang of machinery, brilliant scientific applications, the bustle, etc., "are more conspicuously in the eyes of the public than the quiet, persistent, unromantic, but heroic fight with unseen but unwholesome influences which lurk in the air of our towns. These influences, mostly growing out of our modes of life, are ever present in all our cities, ever growing unless checked, always producing disease, and from time to time especially inviting pestilence." Few cities can afford to allow a pestilence to invade them. "A single epidemic, but one fourth as bad as that of Memphis last year, would cost this city," says Professor Brewer, speaking of New Haven, "more, and leave us with higher taxes, than the most expensive system of sewers and of garbage collection that was ever dreamed of here." Moreover, a pestilence is only an intensified manifestation of disease, and most of its disastrous effects may be produced by prolonged but general ill health; and it is perfectly safe to say that no Northern city can be really prosperous and really sickly at the same time.

The Mound-Builders.—The report of retiring President Pratt, of the Academy of Sciences of Davenport, Iowa, gives especial attention to the researches respecting the mound-builders, in which this association is much interested. One of the members of the society, the Rev. Mr. Gass, explored seventy-five mounds during 1880, about fifteen of which afforded relics to be deposited in the museum. According to the evidence of the mounds in the vicinity of Davenport, copper was a rare and highly valued article among the people who built them, so rare as to indicate that they did not work the copper-mines of Lake Superior or any others, and were not in communication with any people who did. The amount of drift copper still found in the region indicates that a sufficient supply for all that the mound-builders seem to have had could be accounted for from that source. The copper was all hammered; no evidence exists of any of it ever having been smelted or cast. The so-called copper axes do not seem ever to have been used as tools, and are supposed to have been kept as badges of wealth and distinction. The mound-builders smoked tobacco, but, as is inferred from the form of the pipes, ceremonially rather than for enjoyment. Among the great variety of animal forms represented on the pipes, two distinctly resemble the elephant, mammoth, or mastodon. Mr. Pratt declares that the Davenport Academy has evidence—the only evidence discovered so far—that the mound-builders had a written language. It exists in the shape of two inscribed tablets found in the mounds and deposited in the museum of the society, which have attracted considerable attention in this country and Europe, and to which, provided their genuineness can be maintained, much importance is naturally

attached by archæologists. They were kept at the Smithsonian Institution for two months, and were carefully examined there by members of the National Academy of Sciences as well as by other persons; heliotype plates were taken of them, and they were exhibited at the meeting of the American Association at Boston last August. Mr. Pratt believes that the evidence of their genuineness is sufficient. The society's collection of mound-relics is regarded as one of the best in the world.

The Saliva and the Gastric Juice.—Recent researches reported by M. Defresne throw new light on the relations of ptyaline, diastase, and the gastric juice. It has been debated whether the saliva is destroyed in the gastric juice or continues in the stomach its action on starch. M. Defresne's experiments prove that the saliva is paralyzed in pure gastric juice, but that with a mixed gastric juice containing only organic acids, saccharification proceeds as well as in the mouth. Ptyaline, then, differs from diastase in that it is only paralyzed for an instant in pure gastric juice, but recovers its action in the mixed gastric juice and in the duodenum, and is capable of continuing the process of saccharification; while diastase is irrecoverably destroyed in hydrochloric solutions or in pure gastric juice, and is profoundly altered after passing into the mixed gastric juice, so that if it still dissolves starch it no longer saccharifies it. Ptyaline is recommended as an excellent reagent for demonstrating the difference between mixed gastric juice, which owes its acidity to organic acids, and pure gastric juice, the strength of which is derived from hydrochloric acid.

Cutting and Slave-making Ants.—The Rev. Henry C. McCook has contributed to the Academy of Natural Sciences, of Philadelphia, papers on a Northern cutting ant, and on the American slave-making ant, both of which are of much interest. The cutting ant was observed at Island Heights on Tom's River, New Jersey. Entrance to the nest was afforded by a narrow tubular gallery about two inches long, which led to a spherical chamber about an inch and a half in diameter. This chamber, or vestibule, communicated with another chamber, also generally spherical, but of more irregular outline, three and a half inches in diameter, within which were several masses of leaf-paper similar to that made by the Texas leaf-cutting ant, but exceedingly fragile and without the cellular arrangement of the Texas paper. In pleasant weather the insects worked in two columns, one going each way—to the pine-trees and returning to the nest—and moving very deliberately. Those in the column returning homeward were carrying little pieces of the pine-needle or leaf, cut from seedling plants. They bore the load on the head, with one end held firmly by the mandibles, and the effect at a little distance was "to give them a shoulder-arms appearance." In cutting the leaf, the ant climbed out to a position near the end and applied her mandibles, moving around as she cut, till the piece was severed and fell. The architecture of the caves was a miniature copy of those of the Texas cutting ant. All the colonies were comparatively small, and without visible connection with each other. The slave-making ants (*Polyergus lucidus*) were studied near Altoona, Pennsylvania. They occupied a chambered nest which was furnished with four gates, and extended to the depth of at least twenty-two inches underground; but the chambers were without orderly arrangement, apparently on account of the gravelly nature of the soil in which they were built. Mingled in large numbers with the *lucidus* ants were working insects, of the species *Formica Schauffussi*. Two days after the nest was disturbed, the working ants were observed cleaning out the galleries, with the apparent intention of closing the openings. Others were engaged in a migration, taking up the mistress ants by interlocking mandibles with them, and carrying them off up the perpendicular face of the cutting for eighteen or twenty inches, and then for the distance of six feet over the ground and through the grass. "More than once a slight opposition was made to this treatment. The slaves, or at least certain individuals of them, . . . seemed at times to have a prejudice against the presence of *lucidus* ants above-ground, and would unceremoniously seize them and carry them

below. I have seen a master, or more properly 'mistress,' thus served several times, each time returning in a dogged sort of resistance to the will of her servitor. These inert mistresses, too, apparently know something of the bitterness of bondage to a capricious domestic help!" In the course of the migration, one queen was seen to resist carriage so vigorously that she was finally dropped, and, refusing to give the slave a hold on the mandibles, was seized by the wing and dragged off. "The *lucidus* ants seemed to have no volition in or direction of this movement. I released a number from their porters during various stages of the transit, and they always wandered about with a confused, aimless, and irritated manner until again seized and borne off by slaves." Some of the ants were colonized in Philadelphia, and observed more closely. The masters were never seen to work. "The colony was changed several times in order to incite to new work in mining galleries and rooms; clusters of *lucidus* were placed by themselves; they always remained idle. The slaves wrought with the greatest industry and energy as long as there was any need: the masters would crowd into the galleries, and move about in an aimless way, but I never could trace any attempt either at directing or aiding in the work. So, also, I never saw one attempt to eat. . . . Yet they are in good condition, and evidently well fed. They are doubtless fed by the workers, who must disgorge the food." But Dr. McCook could not see this going on. The *lucidus* ants and the workers both seemed fond of the light, even of the artificial warmth and light of the gas-light globe, where they would "congregate in the comfortable glow." The association of the two species in their singular relations has resulted in developing the warlike faculties of *lucidus* at the expense of its disposition to labor; but has not operated to degenerate the soldierly courage and faculty of *Formica Schauffussi*, the working ant, for the individuals of this species will spring to repel a hostile attack as freely and fiercely as their masters, and will do it independently, too; and they are quite as able as ready to wage sucessful warfare. The *lucidus* ant appears to be spread over the whole continent, except perhaps in the far south.

Improved Electric Motor.—A new form of dynamo-machine has recently been devised by Mr. C. F. Heinrich, which the "Telegraphic Journal" pronounces an important advance upon previous constructions. The main improvement is in the form of the armature, which the inventor has been led to adopt by a careful study of the Gramme ring and the way in which currents are induced in it. He finds that the inner side of the ring (that farthest from the field magnet) produces on the coil a current opposed to the one induced on the part of the coil immediately in front of the poles of this magnet, and to this extent weakens the current and causes heat in the coil. When the field magnet is powerful and the ring thin, this effect is reduced, but the inductive action of the farther side of the ring is not wholly eliminated. He therefore makes the ring channeled, or of horseshoe cross-section, the coils of wire being wound on the outside only. This removes the metal from the inner portion, and at the same time allows such a free circulation of air around the wires of the coil where they cross the base of the horseshoe that heating is effectually prevented. The ring is mounted and revolved between the poles of the field magnet in the same way as on the Gramme machine.

Geological Features of Behring Strait.—Some curious geological features are noticed in Mr. W. H. Dall's report of his last summer's work in the coast and geodetic survey of Alaska and the vicinity of Behring Strait. The country is not wholly without attractions, for when, on the 20th of August, the surveying-vessel, the Yukon, anchored behind Cape Lisburne, on the American shore of the Arctic Ocean, nearly two hundred miles north of Behring Strait, the air was balmy, the sun was warm and bright, no snow or ice was visible, and the banks were covered with flowers, among which daisies, monk's hood, and forget-me-nots were conspicuous. At Point Belcher, too, the vegetation was quite dense. Beds of good coal, belonging to the true Carboniferous period, are found at Cape Lisburne, from which the revenue cutter Corwin was satisfactorily coaled several times. Large lumps of coal lay on the beach at

Point Belcher, which had been pushed up by the ice from the bottom of the sea. The peculiar geological feature of this region is a great formation of ice which seems to have the characteristics of a regularly stratified rock. At Point Belcher, pure ice is met at two feet below the surface, and is of unknown depth. At Elephant Point, Kotzebue Sound, the clay banks gradually rising along the beach to the eastward show successively two perpendicular faces of ice, "solid and free from mixture of soil, except on the outside," one above the other. The ice-face nearest the beach is covered with a coating of soil which bears a luxuriant vegetation. The whole formation, including the talus in front of the ice, may be about thirty feet high. Above this is a second talus, on a larger scale, ascending to the foot of another ice-face, which is also covered with herbage-bearing soil. The brow of the second bluff is about eighty feet above the sea; from it the land rises gradually to a rounded ridge three or four hundred feet high. At the height of two hundred and fifty feet a frozen stratum was found containing lumps of clear ice, that indicated the existence of solid ice, at no great depth below. Hence it is inferred that the whole ridge, two miles wide and two hundred and fifty feet high, is chiefly composed of solid ice overlaid with clay and vegetable mold. The ice generally has a semi-stratified appearance, is only superficially soiled, is granular in structure for the outer inch or two, and internally solid and transparent or slightly tinged with yellow; but is never greenish or bluish, like glacier-ice. Small pinnacles of ice run up into the clay in places, while in other places the ice itself is penetrated with deep holes in which clay and vegetable matter have been deposited. Holes were seen in the clay-molds of spurs of ice that had been melted away, and cylinders of muck and clay were found on the ice-face, that had once filled holes from around which the ice had melted. A strong, peculiar smell was often noticed, apparently emanating from dark, pasty spots in the clay. It was supposed to proceed from the decomposition of the remains of soft parts of mammoths and other animals. Birches and alders seven or eight feet high, luxuriant herbage, and plants bearing delicious berries, grew with their roots less than a foot from perpetual solid ice. Observations on the water in the strait showed that it is warmest toward the American side, and becomes gradually cooler toward the Asiatic side; that the temperatures are nearly uniform from top to bottom, precluding the idea of the existence of a sub-surface current from the Arctic Ocean which carries cold water to the south; and that the northerly current through the strait and along the Arctic Ocean is probably chiefly dependent on the tide for its force and direction, and upon the warming of shallow waters for its high temperature.

Minnesota Academy of Sciences.— The Minnesota Academy of Sciences was organized seven years ago, and is now free from debt, and able to report its library and cabinet in creditable condition. Although it has had to encounter a lack of sympathy from part of the community, on account of an apprehension that its tendency might be toward infidelity, the retiring President, Dr. F. L. Hatch, declared at the annual meeting last January, that in none of the papers read and published under the sanction of the Academy had any dogma of any one's faith been touched, or a derogatory reflection been cast upon the Christian's sacred record. Professor N. H. Winchell, the incoming President, made an address at the annual meeting, maintaining the right and duty of the State to establish and support institutions for the higher education. He endeavored to show that the denominational colleges and universities had been backward in responding to the demand for the provision of more liberal courses of scientific instruction; and that no general movement was made by them in this direction till a system of scientific schools had been established by private enterprise and State aid, independently of them, and in the face of their indifference to the scheme.

Units of Electrical Measurement.—The International Congress of Electricians, to be held in Paris during the summer, will doubtless be called upon to consider the subject of a uniform standard for electrical measurements. The system of standards at present most used was adopted by the British Association after eight years of study and experi-

ment by a committee. In it all the units of measurement are referred to three fundamental units, the centimetre, the gramme, and the secund, whence it is called the centimetre-gramme-secund system of units (expressed by the symbol C. G. S.). The units practically employed—multiples or sub-multiples of the fundamental units—are the *ohm*, or unit of resistance (symbol R.), the *volt*, or unit of electro-motive force (symbol E.), and the *weber*, or unit of intensity (symbol I.). Their relation to each other is expressed by the equation, $I = \frac{E}{R}$, whence, the value of two of the elements being known, that of the other can be determined. The unit of resistance, or ohm, is determined by a long and complicated formula, so that it is easier to get it at once by comparison with the material standard which is kept at London. Graduated resistance-boxes containing electric coils carefully adjusted to the resistance-force they are intended to represent, are sold by the instrument-makers. Some idea of what the ohm is may be given by saying that a wire of pure copper a metre (or $39\frac{1}{3}$ inches) long and a milimeter in diameter (or about $\frac{1}{25}$ of an inch) represents a resistance of one fiftieth of an ohm; consequently, fifty metres, or one hundred and fifty and a half feet of such wire, will represent an ohm. Common copper wire offers a stronger resistance, so that only thirty or forty metres of it are required to represent an ohm. The volt, or unit of electro-motive force, is not represented by any actual exact standard, but several constant piles exist, the force of which has been exactly measured, which may be referred to. A Daniell battery, having its copper immersed in a saturated solution of sulphate of copper, and its zinc in a saturated solution of sulphate of zinc, has a force of 1·079 volt. The electro-motive force may be measured in practice by using galvanometers which are graduated in volts, the exactness of which is proportioned to the amount of the resistance they offer. One weber represents the intensity of a current having a force of a volt and passing over a circuit which offers an ohm of resistance. The intensities of currents in ordinary industrial use are represented by fractional units of the weber, the *milliweber*, or thousandth of a weber, for telegraphic, domestic, and medical currents, the *microweber*, or millionth of a weber, for telephonic currents. Telegraphic currents vary in intensity from five to twenty milliwebers; the currents of the Gramme machines that feed the Serrin regulators, of from twenty to thirty webers. Some machines used in electrotyping afford still more intense currents, often exceeding eighty webers, although their electro-motive force is very feeble. In France they sometimes measure by the kilometre of resistance, meaning by that the resistance which is offered by a telegraphic wire four millimetres or about one sixth of an inch in diameter, and a thousand metres or five furlongs long, which is equivalent to about ten ohms. The unit of Siemens (U. S.), employed in Germany, represents the elastic resistance of a column of mercury having the length of a metre and a section of a square millimetre, and is equivalent to 0·9536 of an ohm. Several units of intensity founded on the chemical action of electric currents are in use—such, for example, as may be founded on the quantity of gases disengaged in a minute by a voltameter placed in a circuit, or the amount of copper that may be deposited in an hour in an electrolytic bath which is traversed by the current to be measured. Standard apparatuses have also been made, so graduated as to furnish on a simple reading the intensities in webers and microwebers.

German Anthropology.—The German anthropologists are making a study of the relative distribution of blondes and brunettes in aid of their investigation of the origin and ethnological composition of the German people. The reports on this subject, presented by Professor Virchow to the recent German Anthropological Congress, seemed to indicate the existence of centers of light-colored populations in Schleswig-Holstein, the country of the lower Elbe, Hanover, and Pomerania, and of dark-colored stocks in Bavaria, along the Rhine, in western Belgium, and in Switzerland. No superiority over the other is ascribed to either complexion, but the difference is one of original stocks. The blondes appear to have come down from the northeast of Europe and pressed the native dark

race upon the mountain-spurs and the upper valleys. Herr Eckert reported to the Congress concerning the progress he had made in determining the differences in the skulls of the sexes. The feminine skull appears to be marked by a smaller volume, greater delicacy in the contours of the orbits and the structure of the jaws, the absence or inferior importance of the frontal sinus, a more gradual passage from the forehead to the root of the nose, and a flattening of the parietal bone. A discussion took place respecting some Arabic silver ornaments and filigrees of the tenth and eleventh centuries which have been found in Northern and Eastern Europe. Virchow has concluded, from the occurrence of these articles, that an extensive trade existed in the ninth and tenth centuries between the regions of the Volga, the Baltic ports, and the northern countries, and the coasts of the Black Sea and the East. These Arabic ornaments are very abundant in the province of Posen, in some parts of Russia, and in Gothland, and Arabic coins are found in Norway and Iceland. A paper was presented by Professor Ranke, based on the statistics of recruits for the year, which appeared to show that a relation exists between the character of the country and the size of the men who inhabit it. The higher mountain-regions appear generally to produce the larger men. M. Kollmann, of Switzerland, read a paper showing that prognathism, which is believed to be an exclusive mark of inferior races, is of frequent occurrence among civilized people. The prognathous jaws which have hitherto been found in Europe have been considered as abnormal cases, or as examples of alveolar prognathism; but it is impossible exactly to separate alveolar from real prognathism. Some skulls from the heart of Germany, by whatever rules or lines they are measured, show a greater degree of prognathism than those of the negroes of Australia; and the conclusion can not be avoided that this feature is shared to a considerable extent by civilized people. An interesting communication was made concerning the skull of Emmanuel Kant, whose remains had been exhumed in order to place them in the tomb built for them by the city of Königsberg. Two skeletons were found together, but the remains of Kant were identified by comparing the skull with the cast which was preserved in the archives of Königsberg, with which it was found to correspond exactly. The bones of the nose were turned toward the right, and the superciliary arch had a greater development on the same side. The greatest cranial length was 182 millimetres, the height 132 millimetres, and the breadth 161 millimetres, while the mean breadth of Prussian skulls is only 144·6 millimetres. The forehead had none of the majesty attributed to a thinker; it was not broad, and was a little retreating. The temples had a fullness that compensated for this lack, and the left temple showed a protuberance in the region of the third frontal circumvolution, the region in which the faculty of controlling articulate speech is supposed to reside. The only extraordinary feature of the face was the height of the orbits.

Life and Nature in the Campos.—Dr. D. Christison's narrative of his journey to central Uruguay, given before the Royal Geographical Society last fall, is full of curious illustrations of the primitive character of the life in a country which, although it has great capacities for development, is as yet hardly known abroad. The region to which the description applies is the *estancia* of San Jorge, on the south bank of the Rio Negro, almost in the center of the republic, which embraces an area of three hundred and sixty-four square miles. The journey from Montevideo was made in a *diligencia*, an open omnibus in three compartments, holding twelve passengers, and drawn by six half-broken or unbroken horses, which are driven in a manner peculiar to the Campos. In order to prevent accidents from unperceived faults in the roads, a *cuartiador* rides about twenty yards ahead of the team and conducts it by means of a rope which at one end is fastened to the wagon-pole and loosely connected with the bridles of the leaders, and at the other end is attached to the saddle of his own horse. The stages are short, but the stops are very long, for the horses have to be driven in from the plain, and much talking has to be done before those which are needed are lassoed and harnessed to the wagon. "Sometimes an animal is selected,

which has never been harnessed or handled before, and it is only after a long struggle, requiring the utmost skill and strength of the *mayoral* and his assistants, that it is subdued, great roughness being used in lassoing and throwing it, while it is approached and handled gently in harnessing." The road, like all the main routes in Uruguay, is called the *camino real*, or royal road, but the roads are all mere tracks over the Campos, chosen so as to avoid the steepest hills and seek the easiest places to ford the rivers. As a rule, the country can be crossed by ordinary stage-coaches on the natural turf in either direction. The landscape is tame and monotonous, disposed for the most part in low, gently sloping downs or ridges, rising from sixty to two hundred feet above the valleys, "covered with grass and generally unbroken by tree, bush, or rock." The ridges are not furrowed by ravines, and show no traces of erosion. Signs of human habitation are rare. In a few instances the view was relieved by two or three ombie-trees (*Phytolacca dioica*), "large, handsome, shady trees, with soft, pith-like stems." Near Florida were observed groups of stones, like cairns, "consisting of squarish blocks arranged in an artificial-looking manner," a similar formation to which, fifty miles farther west, called Serra, constitutes a true though miniature mountain-range, and has been compared by Dr. Burmeister to the "Teufelsmauern" and "Felsenmeere" of Germany. The district of San Jorge, judging from the rocks of the dividing ridges, rests on a formation of volcanic origin, and is remarkably well watered by the Rio Negro and its tributaries, the Carpinteria and Chileno, with numerous streams flowing through it. The mass of the country is covered with grass but destitute of timber, while the rivers are fringed with *montes*, dense belts of trees and shrubs. The grass is coarse and bunchy, endures the droughts of ordinary summers, and is profusely adorned with *compositæ*, yellow and purple oxalis, white, red, and scarlet verbenas, many liliaceous plants, and a fine œnothera. The only native tree on the Campos is a thorny tala (*Celtis tala*). The *montes* are of comparatively insignificant area, and are composed chiefly of willows, coronillos, laurels, the fruit-bearing guayavo, prickly climbers, and brush-wood, comprising more than twenty species in all. The larger animals—the jaguar, puma, great ant-bear, and large deer—have nearly disappeared, but the smaller animals and the rodents are well represented. Birds are numerous and extraordinarily tame. Eagles would let the traveler throw clods at them and almost touch them, and the rhea ostrich would allow a man on foot to approach to within seventy yards before walking or trotting off. The most important insect is the leaf-cutting ant, which has been often described. It parcels out the Campos among its communities, the nests of which are generally about a hundred yards from each other, with five or six paths radiating from each till they approach the domains of their neighbors. Along these paths double streams of workers are constantly passing to and from the country, each ant of the returning stream holding aloft a piece of grass, a leaf, or a flower. Gardens must be protected against them by destroying the nests with boiling water or poisonous solutions—a difficult task, which has to be carefully done. Another insect plague is the *bicho moro*, a blistering beetle, which attacks the potato-fields and eats regularly forward with almost incredible rapidity.—The return-journey to Montevideo was made in a bullock-wagon, a solidly built vehicle with an arched roof of zinc, perched on high, broad wheels made of pieces of wood so skillfully wedged together that every shock made them firmer, and drawn by means of a shaft which is of one piece with the body. The three or four yoke of powerful oxen, which form the team, are driven by a *picador*, who rides alongside, and the whole train, of which a single one of the wagons is only a member, is under the command of a mounted *carretero*, or patron. The rate of traveling is estimated at from twenty to twenty-four miles a day, but is largely dependent on the weather.

Physiology of Arsenical Poisoning.—MM. H. Caillet de Poncy and C. Livron, of the Medical School at Marseilles, have found that, when poisoning by arsenic takes place, the phosphorus which exists as phosphoric acid in the brain is replaced by arsenic. The substitution takes place in the *lecithine*,

a very complex nitrogenized compound, which thus becomes transformed into an insoluble albuminoid substance. In acute poisoning there is no time for the arseniated lecithine to be subjected to physiological reactions and be eliminated, and the animal dies under the local influence of the poison without sensible variation of the normal phosphorus of the nervous matter. In slow and chronic poisoning the replacement takes place slowly; arseniated lecithine is formed, and acts as ordinary lecithine, passing gradually into the insoluble albuminoid state, while the phosphorus is steadily diminished, giving place to the arsenic.

The Otto of Roses.—The otto of roses consists of an odoriferous liquid containing oxygen combined with a solid hydrocarbon called *stearoptene*, which is destitute of perfume. The quality of the oil is determined by the relative proportion of these substances, and that is dependent chiefly on conditions of climate. The Bulgarian oils contain about eighteen per cent., the oils distilled in France and England as much as thirty-five and even sixty-eight per cent. of stearoptene. The difference in the proportions is also shown in the higher temperature required to melt the oil which contains a greater relative amount of stearoptene. The Bulgarian oil melts at from 61° to 64°, French and English oils from 70° to 89½°. Even in Bulgarian oil a notable difference is observed between that produced on the hills and that from the lowlands. The most important source of otto of roses is a small district in Bulgaria or East Roumelia, stretching along the southern slopes of the central Balkans, and approximately included between the twenty-fifth and twenty-sixth degrees of east longitude and the forty-second and forty-third degrees of north latitude. A suitable soil for the growth of roses is furnished, with need for but little manuring, by the decomposition of the syenite, which is the characteristic rock of the region. The average summer temperatures of the district are 86° at noon, and 68° in the evening. The rose-bushes do best on sandy slopes having a good exposure to the sun. The flowers of bushes which grow on inclined ground are much richer in oil, and that of a stronger quality, than those raised on level land, and are therefore more esteemed and dearer. The flowers when fully expanded are gathered before sunrise, often with the calyx attached, and should be treated the same day. In Bulgaria, roses which have matured slowly in moderately cold weather furnish the richest yields; in England, the contrary appears to be the case. The flowers are distilled for an hour and a half, with double their volume of water, in a copper still from which a pipe passes through a tub that is kept constantly cool by inflowing spring-water. After the distillate has been allowed to stand for a day or two at a temperature exceeding 59°, the oil is skimmed off from it. The residual liquors are used instead of spring-water for subsequent distillations. The rose-water which comes over last is extremely fragrant, and is much prized for medical and culinary purposes. Pure otto, carefully distilled, is at first colorless, but speedily becomes yellowish; has a specific gravity of about 0·87, boils at 444°, and solidifies at from 51·8° to 60·8°, or at higher temperatures in the case of inferior oils, and is soluble in absolute alcohol. It is tested by its odor, which can be judged only after long experience; its congealing-point (a good oil should congeal in five minutes at a temperature of 54·5°), and by the crystallization of the stearoptene with light, feathery, shining plates filling the whole liquid. It is sometimes adulterated with spermaceti, which may be detected by its readiness to solidify, and by other essential oils, the effect of which is sometimes to lower the congealing-point. Rose-water and otto of roses are also produced in India; in Persia, where the trade, formerly important, has nearly disappeared; in the Mediterranean countries of Africa, and in France. The otto of the Provence rose has a characteristic perfume, which arises, it is believed, from the pollen of orange-flowers, which is brought by bees to the petals of the roses.

Effects of Petting on Animals.—Mr. A. D. Bartlett, of the Zoölogical Gardens, London, has remarked that while adult carnivorous animals—lions, tigers, leopards, etc. —can seldom be tamed and then only at the cost of danger, the young become very tame and fond of those who feed and caress

them; on the other hand, housed vegetable-feeding animals—stags, antelopes, oxen, sheep, and goats—if reared by hand from birth, become when adult the most dangerous animals to be met with; while, if caught after they have grown up, they are timid and fly from man. His experience with all animals of the latter class has been the same as with the lamb, whose case he describes, that was brought up as "one of the family." As it grew larger and stronger, it became self-conscious and independent, having "no fear and less gratitude," and grew so saucy that it had to be consigned to a large field, where it became a terror to passers—for, "with hop, skip, and jump, he was behind any one in an instant; with one good spring, the unfortunate traveler was on his hands and knees if not on his face"—and was finally sentenced to the butcher. Such of these animals as have been bred in captivity (not petted and handled) and reared by the parent, become exceedingly wild if an attempt is made to catch them, pack them up, or move them from one place to another. The reason for these curious manifestations appears to be that the tamed animals, having lost their fear of man and become familiar with him, when the time comes for them to manifest their belligerent propensities, have no respect of persons, and are ready to attack their former friend as they would any other real or imaginary antagonist; but, when anything new is attempted with them, it is as novel as it would be in their natural state, and awakens all their natural wildness.

Fungi as Insecticides.—The possibility of putting a limit to the depredations of noxious insects by cultivating the fungi which are destructive to them has been several times suggested. Professor Le Conte recommended the study of the epidemic diseases of insects, particularly of the fungoid diseases, with this view, in 1874. Charles H. Peck, State Botanist of New York, advanced a similar idea with reference to the fungi which infest plants, in 1876, and in 1878 described a large destruction of seventeen-year-locusts and of the larvæ of insects feeding upon the alder by fungi. Dr. H. A. Hagen, of Harvard University, in 1879, thinking he had established the identity of the fungus which destroys the house-fly with the yeast-fungus, recommended the use of the latter against noxious insects in general. Professor A. N. Prentiss, of the Botanical Laboratory, instituted a series of experiments during the spring of 1880 with the plants in the laboratory, upon the effects of the yeast-fungus upon the aphides and other insects preying upon them. The record of his experiments is given in the form of a journal in contributions to "The American Naturalist." The result of nine experiments as a whole, as also of many others not recorded, indicates that yeast can not be regarded as a reliable remedy against such insects as commonly affect plants cultivated in greenhouses and dwellings. The attempt to use it is liable to the further objection, that it will be very likely to injure many kinds of plants quite as badly as it will the insects. The experiments of Mr. Trelease, of Selma, Alabama, with the yeast upon the cotton-worm, led him to a similar conclusion with reference to its application to that insect. On the other hand, according to Dr. Hagen, Mr. J. H. Burns, of Shelter Island, New York, has had some success with yeast against the Colorado potato beetle, and it has been used upon the aphides in a greenhouse in Germany with great success. Professor Prentiss does not consider the question at issue decided by his experiments, for the yeast-fungus may be operative on other insects and under other conditions than those with which he performed his experiments, and there may be other forms of fungus which, applied with discrimination, would be effective.

Examination of Germs in the Air.—Dr. Ferdinand Cohn and Dr. Miflet, of Breslau, have been investigating experimentally as to the possibility of detecting the organisms which are regarded as the germs of infection and fermentation in the air in which they are supposed to float. Their experiments were carried on from the middle of March to the end of July, 1878, in the air of laboratories, operating-rooms, and the sick-rooms of hospitals; in the free air of the botanical gardens, and the air gathered at the surface of the soil of the garden; and in the sewer-air of a court. They found—1. That numerous germs exist in the air in

a suitable condition to undergo development; 2. That these germs could be collected by the methods they employed, could be made to develop and multiply, and could be systematically distinguished and described; 3. That the presence of some of the germs which are commonly developed in fermenting substances was not detected in the air; 4. That the presence of germs of particular kinds was detected in air taken from the surface of the soil; 5. That the air of the sick-chamber of a typhus-hospital appeared to be singularly free from germs capable of development, a result which was attributed to effective ventilation and disinfection; 6. That the air rising from the sewer was rich in living germs; 7. That the number of observations and experiments in this their first systematic investigation is not yet sufficient to enable them to determine whether the difference in the number of germs collected from the air in different places may be taken as indicating a difference in the healthiness of the several localities—so far, they seem to give a negative result.

Forestry in India.—An address by Sir William Temple, before the Society of Arts, on "Forest Conservancy in India," calls attention to the vast destruction of forests which that country has suffered in common with other populous lands. Traditions show that the country was once covered with sylvan and other vegetation, but this dress has been removed, as the demands of man upon the surface have increased, and the most important forest-growths are now found on the mountain-ranges. The trees of India may be divided into two classes; those of the Himalayas, and those of the other mountain-ranges and the plains. The trees of both classes are magnificent specimens of growth. The Himalayan trees are allied with those of Europe and other temperate regions, and embrace, among the *Coniferæ*, the cedar, the *Pinus longifolia*, most valuable timber-trees; the cypress, the fir, the yew, and the juniper, the latter the only valuable tree that grows near Quettah. Of the other orders are the ilex, oak, and walnut, of Simla,the plane-tree of Cashmere, the maple, magnolia, laurel—here a great tree—the rhododendron, and the tree-fern, most graceful of plants. The other mountains produce the teak, the iron-hearted sal, the anjun, with its white, bright, and smooth trunk like a great marble pillar; the saj, which often grows close by the anjun, and, having a black and rough trunk, offers an effective contrast with it; the black-barked bije sal; and the white-barked, weird-looking frankincense-tree. The plains furnish the babul, or acacia, the one tree which is universal in India; the mango, the figs, among which are the banyan; and the India-rubber tree, bamboos, and palms in their varieties. The demands of the population for wood are immense, with thirty-seven million houses in British India, and one fifth as many in the native states, to be supplied, and all the implements of a people with whom iron is in comparatively little use. On account of the scarcity of wood, the people are obliged to burn manure for fuel, and thus to rob the soil of what should be returned to it, adding another to the agencies which are steadily impoverishing it. The absence of woods can not affect the total rainfall of the country, for the vapors that rise from the sea must be condensed somewhere, but it seriously affects its disposition. The clouds pass over the hot, dry plains, and precipitate their moisture upon the mountains, where they cause swift torrents to rush down into the lower country and create destruction there. The capacity of the soil to retain moisture is destroyed, and the water which would be stored in the natural forest through the dry season is lost in a sudden drought. A Forest Department has been created by the Government within the last twenty years, and gives special attention to the preservation of the remaining forests, of which the whole extent is about seventy thousand square miles. These forests are divided into the "reserves," or forests which are carefully guarded, embracing about twenty-five thousand acres, and the "protected" forests, which are imperfectly guarded and preserved. The forests of both classes have been decided to be the property of the Government. The reserves are placed directly under the care of the Forest Department. The protected forests are managed by the ordinary civil officers, under the supervision of the Forest Department. The management is directed to the

regulation of the cutting of timber, to the control of the practice called "rab," or of cutting the new shoots and twigs of trees to be burned for manure, to the prevention of jungle-fires, and to the regulation of pasturage by establishing blocks, or areas of forest range, to which grazing may be confined, while other blocks are held in reserve to be entered upon after the grass of the former blocks has been consumed. The restrictions are imposed only in those forests which have belonged from time immemorial to the Government, as well under native dynasties as under British rule; and, where subordinate rights exist, they are recognized and defined. Areas of jungle, of equal—probably of more than equal—extent with the forests, and ample for the general local use of the natives, have been everywhere marked off as belonging to the people, and are accessible to them without restriction. The "reserved" and "protected" forests furnish first and second class timber and excellent fuel. The management of the Forest Department has so far been attended with a considerable profit to the revenue of the state.

A New Disinfectant.—When warm air is forced through a hot mixture of turpentine and water, a disinfecting substance known in commerce as *sanitas* is produced. It is an aqueous solution, characterized by the presence of peroxide of hydrogen and certain camphoraceous substances. With it is found another substance, called *sanitas-oil*, also containing peroxide of hydrogen, which possesses a high power of oxidation. According to the account given of it by Mr. C. T. Kingzett, the oil promises to become very valuable for sanitary purposes. As it has been found an efficient agent for the decomposition of so stable a substance as iodide of potassium, it can hardly be doubted that it will also effect the oxidation of any animal or vegetable substances, particularly those which are in course of putrefactive decomposition. It has also the property of being capable, after having once performed its measure of oxidation, of forming a new amount of active peroxide of hydrogen, which may be made available for further work. Several experiments, made by Mr. Kingzett, prove that this oil is a powerful antiseptic. Beef put in water containing it was kept sweet during periods of twenty-five and forty days; flour paste from thirty to fifty days; the white of eggs for fifty days; wine for one hundred days. The oil is not destined to supersede the sanitas, for it is too powerful in its action to serve the purpose to which the aqueous solution is applied, and is not adapted to meet the same ends, but be a valuable supplement to it. It may be added to glycerine, oils, or ointments, when they are applied to the body in cases of infectious disease. It may be evaporated for the fumigation of rooms which have been occupied by persons suffering from communicable diseases. Plane surfaces, as floorings and walls, may be disinfected by wiping them with a cloth or brush which has been dipped in the oil; and only a small quantity of oil is necessary for this purpose, for it spreads freely. It is slowly volatile, and may be used as an aërial disinfectant. The emulsion in water may be applied in a great many places; and sprinkled over sawdust it may be employed as an effective deodorant.

The Color-Sense among Uncivilized Peoples.—Dr. Hugo Magnus, of Breslau, has just published a work containing the results of inquiries which he has made into the power of uncivilized people to distinguish colors. He sought to ascertain from direct evidence the extent to which the color-sense already exists among savages, and how great is its capacity for development, and to collect the terms by which they express their distinctions of color. He prepared a set of questions relating to the most marked colors, such as black, gray, white, red, orange, yellow, green, violet, and brown, omitting those shades to distinguish which some degree of education is obviously necessary, and sent them to physicians, missionaries, merchants, and other persons in different parts of the world having intercourse with native races, who seemed able to afford information on the subject. As a whole, he has found that the color-sense of the ruder nations is circumscribed by limits differing but little from those which bound the same sense among civilized people. In no race did he find an entire absence of the faculty of

distinguishing between the principal colors. Taking red, yellow, green, and blue, as the chief representatives of the colors of the longer and shorter wave-lengths, there was not one among the tribes coming within the range of the inquiry which did not show some knowledge of these four colors. This knowledge must be considered as only relative, and not as existing in the same degree among all tribes. Savages exhibit important differences in the degree to which their sense of color is capable of cultivation. Some show considerable skill in distinguishing between different mixed and transitional colors, others are less keen to perceive transitional colors, while there are some who are slow in marking the most distinct principal colors without being wholly incapable of it. This dullness is shown chiefly in reference to the colors of the shorter wave-lengths, as green, and more especially blue. There are tribes which have surprisingly little knowledge of these colors; among them are some of the aboriginal tribes of southern India, whose color-sense is developed only to the perception of red, while their knowledge of yellow and green and blue is most limited and rudimentary. The inhabitants of the island of Nias have one name for blue, violet, black, and green, another for yellow and orange. Numerous observations are cited to prove that the capacity to discriminate between the colors of the longer wave-lengths is sharper than that relative to those of shorter wave-lengths. An English consul in the Loyalty Islands informs Dr. Magnus that the inhabitants of that group understand the differences between colors very well, but confound them in naming them. The negro tribes of Sierra Leone, distinguish between the several colors, and have words to indicate them. Gray and orange are least regarded, and are spoken of as white and red. Blue and green are frequently confounded, but are seldom mentioned as identical. The pastoral Ovaherero, or Damaras, of South Africa, are keen in their appreciation of the shades of color that are marked on their cattle, and have names for all of them, twenty-six terms in all, but have no names for the colors that are not cattle-colors, although they know them apart quite clearly, and will use foreign words in speaking of them if it is necessary. Sometimes, for lack of a better word, they will use their own word for yellow, for blue, or green, but with a clear sense that they are applying it inaccurately. Most of the Damaras have come into some contact with civilization, but no important difference in the capacity to distinguish colors can be found between the civilized and the uncivilized members of the race. The uncivilized, however, although they know them well enough, can not give names to blue and green, and think it strange that these colors should need names. A tribe on the Gold Coast are well acquainted with the difference between red, yellow, green, and blue, but are wholly destitute of terms for the colors of the medium and shorter wave-lengths, and seem to have names only for white, black, and red. Virchow found similar conditions to exist among the Nubians, who were lately in Berlin, and a similar indifference to the colors of the middle and shorter wave-lengths to prevail among them. Most of them were accurate in perceiving and naming the four higher colors of the scale, and black, white, gray, and red, but recognized the other colors with some difficulty. Professor Delitzsch has remarked that the people of the ancient Semitic races had little appreciation of blue. This dullness in distinguishing the colors of the shorter wave-length contrasts strikingly with the sharpness which people of all races display in distinguishing and marking red.

Slaughter of Food-Animals among the Jews.—According to the analysis of Dr. Rabbinonicz, of Paris, the Jewish Talmudic rules concerning the slaughter of food-animals were framed with the special object of providing for the infliction of the least possible suffering upon the animal, and of procuring the meat in the most wholesome condition for food. They prohibit the stunning of the animal by a blow on the forehead, because it is far from certain that the blow immediately annuls pain, and it is certain that it does not annul it if inflicted by an awkward hand. The rules require that the act of killing shall be performed by the sweep of a long, sharp instrument, which shall at once sever, more or less completely, the trachea and œsoph-

agus. They do not require the arteries to be cut, for the nature of those vessels was not known when the rules were made, but the arteries and the important nerves around their sheath are cut in practice, and the animal speedily faints into insensibility, and dies of hæmorrhage. The important points of the code are, that the steps in slaughter shall be continuous, because any interruption, however minute, in the process, is likely to prolong the sufferings of the animal and make it unfit for food; that the cut shall be made by a to-and-fro stroke, without any pressure beyond what is required to carry the knife down to the necessary depth; that the incision in the skin shall accurately coincide in length with the deeper portion, so as to leave no "tail" to the wound; that the wound shall not be made so high as to risk contact of the knife with the bony structures above the cartilaginous rings of the trachea, for this would be likely to cause preventable suffering to the animal, and compel the rejection of its flesh as food; and that no tissue should be torn or jagged. The candidate for a license to slaughter has to go through a long course of preparation, of which a kind of rough anatomy forms a part, and afterward to prove his competency to the satisfaction of the appointed authorities. The heart is also carefully examined, to ascertain whether it is fit for food. The rules on this subject, although made before anything was accurately known of pathology, contribute, as a whole, to the selection of that which is good and to the rejection of that which is bad. The use of the blood is forbidden, and it is in the blood that science to-day tells us the germs and the matters that are detrimental are most likely to be found and to be most active. The lung is the organ most diligently searched and severely tested; and it is the lung which is most liable to disease, and in which, when disease is present, it is most obvious. Fewer directions are given concerning search for morbid conditions in the other organs, "for, as it was known that animals were but rarely perfectly sound in their entire system, a more rigid search would have been nearly tantamount to depriving the people altogether of animal food. But, although a search for other diseased organs is not enjoined, any morbid condition observed by the practiced eye of the slaughterer insures the rejection of the animal as food."

The Origin and Progress of Pisciculture.—M. Ph. Gauckler, in a recent work on fresh-water fishes, has reviewed the history of pisciculture from the earliest times to the present. In modern times, Dom Pinchon, a monk of the Abbey of Réome, in the fourteenth century, hatched fish in boxes through which a current of water was kept slowly flowing. The Chinese practice of placing limbs of trees or herbs in the spawning-places to collect the eggs has been in vogue from time immemorial in Europe, chiefly in the ponds of Bohemia. A Swedish magistrate named Lund, of Linköping, adopted it successfully in 1761, after having casually remarked that eggs which clung to juniper-branches did better than those which fell to the ground. In 1834 Mauro Rusconi, an Italian, successfully propagated the tench, the bleak, and the perch, in the lake of Como; and MM. Agassiz and Vogt began at about the same time their embryological experiments on the *Salmonidæ*, with the view of multiplying one of the species in the lake of Neufchâtel. Mr. John Shaw, of Drumlanrig, adopted artificial culture to increase the product of the salmon-fisheries of the river Nith, in Scotland. His example was followed by Lord Gray, on the Tay, in 1838, and by others in 1841. Joseph Remy, of La Bresse, in the Vosges, made his first experiments in artificial reproduction, having, by his own investigations, discovered a process of which Jacobi had given an account, but which had not attained publicity eighty years before. M. Coste, of the College of France, perceived the importance of this discovery and adopted it in 1850, while he secured a suitable reward to Remy. The attention of several persons in France was directed to pisciculture by the enthusiastic publications of M. Coste, and the experiments of M. de Quatrefages and other members of the Society of Acclimation. They were encouraged by the gratuitous distribution of eggs and fry, which were liberally furnished to French and foreign customers from the establishment of Huningue. During the later years of the French adminis-

tration, the quantity distributed amounted to twenty millions a year for species of the salmon family only. The business of propagation has been extensively carried on in England as a commercial speculation. Since 1854 the Messrs. Ashworth have put 260,000 salmon in Lough Corrib, Connaught, Ireland. A special establishment has been erected at Perth, and Cooper's fish-ladders have been put in all the rivers frequented by salmon. Important establishments for the artificial propagation of salmon have been created in Holland. The basins of the Zoölogical Garden of Ghent and of the Horticultural Society of Brussels have been adopted for purposes of hatching. Several lakes in Switzerland have been largely restocked by artificial means. The most practical results, according to M. Gauckler, in the perfection of processes, have been gained in America, and acknowledgment is freely made of the value of the labors of Baird, Livingston, Stone, Ainsworth, Seth Green, Collins, Mather, and others, in bringing down the science from the domain of speculation to that of palpable facts and remunerative results.

Sanitary Protection Associations.—Sanitary protection associations have recently been formed in Edinburgh and London, the objects of which, as stated in the prospectus of the London Association, are: 1. To provide their members, at moderate cost, with such advice and supervision as shall insure the proper sanitary condition of their own dwellings; and, 2. To enable members to procure practical advice, on moderate terms, as to the best mode of remedying defects in houses of the poorer class in which they are interested. The associations are not intended as a substitute for a municipal inspection, or to conflict with the public authorities, but to supplement their action. The idea of the associations originated, according to the statement of Professor Fleeming Jenkin, the founder of the one at Edinburgh, in a paper read by him before the Society of Arts, in his endeavoring to explain in a lecture the principles of sanitation, so that they could be applied practically by householders. He found that he could not do it, but that, after all his efforts to make the matter clear with general demonstrations and diagrams, professional advice had to be sought by each householder for his own particular case. What advice could the public obtain? The plumber and builder were interested parties, and not always competent; engineers held their services at too high a rate to be readily accessible to the majority; public officers could not be called upon unless there was probably some actual serious defect to be remedied. The thought occurred that an association of householders might be formed, to employ an engineer, at a fixed salary, who should make an inspection, draw plans, and propose improvements, for each subscriber, at an expense to the latter only of his annual subscription. The subscription to the Edinburgh Association was fixed at one guinea a year. The sum has been found enough to answer the intended purpose, and the work has been conducted with entire satisfaction and success in that city for three years. The London Association requires an entrance-fee of two guineas for houses of less than four hundred pounds rental, and subsequent annual fees of one guinea. A person joining either association and paying the entrance-fee obtains all the privileges of membership for a year without committing himself to any further payments. He has a right to a thorough professional inspection of all the water and drainage apparatus in his house, including every pipe, tap, cistern, and sanitary convenience, for efficiency, leakage, smells, and ventilation, and the main drain between the house and the town sewer, the opening of which, however, is at his expense. As soon after the inspection as may be, he may receive a detailed report, describing the condition of his house, accompanied by a sketch diagram showing every pipe and trap, in connection with which recommendations for improvements are made when necessary, with rough estimates of the probable cost if they are desired. The wishes of the occupier are taken into account, the more important are distinguished from the less important alterations, and the suggestions are specific enough to enable the occupier to consult intelligently with his plumber or builder on the subject. The society has no interest in recommending any expenditure, and the occupier has his option whether he will incur

any or not. If he concludes to have the work done, he may have it inspected, when it is completed, or nearly so, and obtain a Certificate as to the sanitary condition of his premises. The second year's inspection is a simpler matter than the first year's, for it is guided by the results of the previous inspection, and has to be only comparative. With respect to the efficiency of this system, Professor Jenkin says that it has been shown that the required services can be rendered in a thorough and efficient manner by one resident engineer, for four hundred and fifty or even five hundred houses in one year. Twelve hundred houses have been put in order in Edinburgh, and there has not been during three years one case of complaint that the houses were not thoroughly examined, or that the reports were not sufficiently detailed; but, at the annual meetings of the society, member after member has arisen to express his satisfaction at the work.

Dust, the Nucleus of Fog.—According to the researches of Mr. John Aitken, as described in a paper read by him before the Royal Society of Edinburgh, the formation of fogs and clouds is dependent on the presence of dust in the atmosphere. His view was illustrated by an experiment in which steam was mixed with air in two large glass receivers, one of which was filled with common air, the other with air that had been filtered. Clouds appeared in the former vessel, while the air in the other one remained perfectly transparent. Similar results attended an experiment with the air-pump, in the receiver of which a little water was placed to saturate the air. On removing a part of the pressure, a fogginess appeared, or nothing was visible, according as the air in the receiver was unfiltered or filtered. From these and other similar experiments, Mr. Aitken has concluded that, whenever water-vapor condenses in the atmosphere, it always does so on some solid nucleus; that dust-particles in the air form such nuclei; that if there were no dust, there would be no fogs, no clouds, no mists, and probably no rain; that the supersaturated air would convert every object on the surface of the earth into a condenser on which it would deposit; and that our breaths, when they became visible on a cold morning, and every puff of steam as it escapes into the air, show the impure and dusty condition of the atmosphere. Experiments with other vapors than that of water showed that their condensation is governed by a similar rule. The condensation is not produced by any particles which we can see, or even by those which are revealed by the sunbeam, for these may be driven off by heat and the fogs still be visible, but by vastly more numerous, infinitesimally small, and invisible particles which heat will not drive away. These particles may be furnished by the spray from the ocean, by meteoric matter, by the operation of almost every force. The products of all kinds of combustion give rise to them. The use of purer forms of coal, or even of gas, does not avoid them, nor even appear to diminish their number. Common salt is one of the most active fog-producers, but the products of burned sulphur exceeded in this respect all the other substances experimented upon. The density of the fog depends on the amount of fine dust in the air. If only a few particles are present, only a few fog-drops form, and they are heavy and fall like rain; if there are many, the more dust the finer are the fog-particles, and the longer they remain suspended in the air. Though the use of more perfect forms of combustion is not likely to prevent the generation of fogs, it will, by preventing the accumulation of smoke which now comes down into fogs and mixes with them, remove the cause which makes them so dark and extremely annoying.

Electric Lights for the French Coasts.—M. E. Allard, Director of the Central Lighthouse Service, has submitted to the French Minister of Public Works propositions for lighting the coasts of France with the electric light. He would begin by substituting the electric light for the present oil-lights in forty-two of the principal lighthouses, and adding sound-signals in twenty of them. The mean range of visibility of the present oil-lights is twenty-two miles on the ocean-coast and twenty-seven miles on the Mediterranean coast. Within these radii they can be depended upon as signals during one half of the year; during the other half of the year

they are liable to be interfered with by unfavorable atmospheric conditions, so as to greatly reduce their radii of visibility. With electric lights having the powers that M. Allard proposes to apply, the period during which the penetrative power may be deficient will be reduced to sixty days, or one sixth of the year on the ocean, and to twenty-four nights, or one fifth, on the Mediterranean coast. The cost of the proposed changes is estimated at seven million francs, or eight million francs if sound-signals are also provided. It is believed that the cost of keeping up the light after the change is made will be several times less than that of maintaining the oil-lamps.

NOTES.

A THERMOMETRIC bureau has been established, in connection with the Winchester Observatory of Yale College, for the more accurate graduation and verification of thermometers. The thermometers in common use are, as a rule, not graduated with any approach to scientific accuracy, and the best of them, however exact they may be when new, increase their readings rapidly within a few months, so as to become as much as 2° in error in the course of a year. This is a matter of particular importance with clinical thermometers, of which several thousand are bought every year; and to instruments of this class special attention is paid.

THE late Mr. Frank Buckland has bequeathed his valuable museum of "Economic Fish Culture" to the British nation, with the sum of £5,000 to go to the nation on the death of Mrs. Buckland, to be applied to the foundation of a professorship of economic pisciculture in connection with the Buckland Museum and the Science and Art Department at South Kensington.

A SUGGESTION to employ artificial lights for the capture and destruction of noxious insects has found considerable favor. A medal was awarded at the last exhibition of agriculture and insectology in Paris for a lamp especially adapted for catching insects. The electric light has been found to be a very effective insect-trap, and its eventual coming into use for this purpose in bug-infected gardens and orchards may be regarded as among the things that are possible.

ARTERIOGRAPHY is the name which Dr. Comte, a French army-surgeon, has given to a novel application of tattooing as a help in the saving of lives. Believing that a large proportion of deaths by bleeding from wounds received in battle might be avoided if the men knew just where to apply compression to the arteries till the surgeon should come, Dr. Comte has marked the most suitable points for the application by tattooed designs on the skins of the men of his regiment.

MR. THOMAS MEEHAN, of Philadelphia, has observed that the *Yucca gloriosa* has the property of collecting moisture on the outer surface of its flowers to such an extent that drops will fall to the ground. In the plant in which this peculiarity was first noticed, the whole outside of the flowers was covered with moisture; it accumulated in drops at the tip of each leaf of the perianth, and the under leaves showed by their appearance that a dropping of water had been going on for some time. Mr. Meehan could not decide whether the liquid was an exudation from the leaves, or had been condensed from the atmosphere through some special property of the plant, like that which is attributed to the rain-tree (*Pithecelobium saman*) of Peru.

CARL WEYPRECHT, one of the commanders of the Austro-Hungarian Polar Expedition in the Tegetthoff, which discovered Franz-Josef Land in 1874, died in Vienna, March 29th.

MM. F. FOUQUÉ and A. Michel Lévy have produced an artificial basalt identical in all respects with the natural basalts, and particularly so with that of the plateaux of Auvergne. The experiment is regarded as establishing the igneous origin of the basalts.

M. LEFRANC has called attention in the "Journal de Pharmacie" to woolen mattresses as a possibly fertile *nidus* for disease. In a large city such mattresses may represent millions of fleeces that have been only partly cleared of grease, and have, moreover, been affected by long use through successive generations. They are rarely efficiently purified, and might become an active medium for the propagation of infection.

SABINO BERTHELOT, an eminent naturalist, died at Santa Cruz de Teneriffe in November last, in the eighty-seventh year of his age. He had made the Canary Islands his home for sixty years, and had done much to increase the knowledge of their natural history. His principal work was the preparation, in conjunction with Mr. Philip Barker Webb, of a series of six quarto illustrated volumes on that subject ("Natural History of the Canary Islands"), which was published in 1828. He was consul of France, and a member of the principal scientific societies of the Canaries and of Europe.

Mr. Potts, of the Academy of Natural Sciences of Philadelphia, observes that the order *Spongidæ* has many more representatives in our fresh waters than has generally been supposed. He recently described to the Academy three species of *Spongilla* which he found in a small stream near Philadelphia. Since then he has found the *Spongilla fragilis* of Leidy plentifully in the Schuylkill below the dam, and a lacustrine form above the dam, and has obtained a very slender green species which appears creeping along stems of *Sphagnum*, etc., in a swamp near Absecum, New Jersey; a beautiful species from the Adirondack lakes; another lacustrine form from the lake near the Catskill Mountain House; and four species from an old cellar at Lehigh Gap, Pennsylvania.

Mr. Edward R. Alston, a British working naturalist of growing reputation, died in London, March 7th. He contributed articles to "The Zoölogist" and other journals, chiefly on mammals and birds, published an account of a journey to Archangel and of the birds he observed there, was engaged in the compilation of the part of the "Zoloögical Record" relating to mammals, and of the new edition (1874) of Bell's "British Mammals," published a revision of the genera of the *Rodentia* (1876), and "Memoirs on the Mammals of Asia Minor" (1877 and 1880), and prepared the "Mammals" of Salvin and Godman's "Biologia Centrali-Americana" (1879 and 1880).

Honor to American Science.—Professor John W. Draper has been elected one of the twelve honorary members of the Physical Society of London, under the presidency of Sir William Thomson.

Professor S. Calvin, of the University of Iowa, not R. S. Calvin, as it was erroneously printed, is the author of the article entitled "A Piece of Coal," published in the March number of the "Monthly."

Dr. James Lewis, a well-known American conchologist, died at his home in Mohawk, New York, February 23d.

"Land and Water" has a curious account of a rat which, feeding upon the oysters in an oyster-cellar in London, was caught by one of the mollusks and held fast by the tail. It adds: "We have seen several instances of mice being caught by oysters. In the collection of the late Frank Buckland were several specimens, but in all these instances the mice were caught by their heads. In one case, two mice had fallen victims to an oyster."

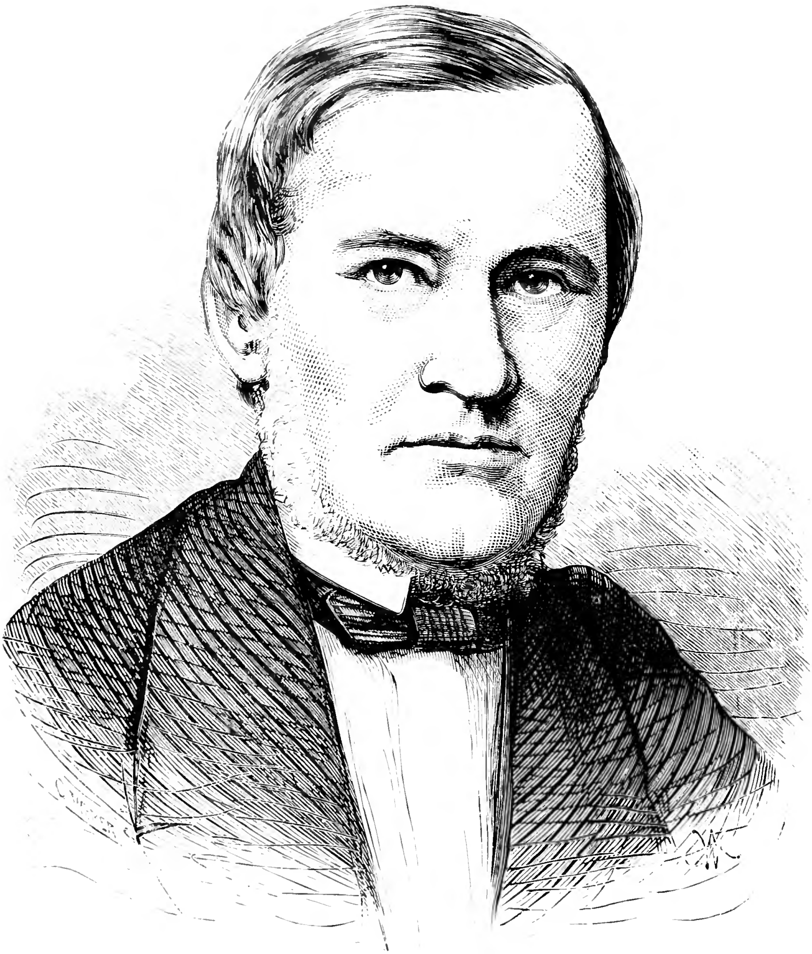
Mr. John B. Hansler has made a study of the source of the drift-ice which accumulates in the harbor of New York during the severe weather of winter, and has traced the principal part of it to the Tappan Zee and Haverstraw Bay. In order to prevent future obstruction of the harbor, he proposes to confine the ice to the waters in which it is formed, by stretching cable-netting across the river at the narrows below the Tappan Zee. The cost of the structures needed to effect the object would be, he believes, less than the amount of damage now frequently suffered from ice in a single season. The presumption that his plan would be sufficient is strengthened by the fact that the bridge of the Central Railroad of New Jersey over Newark Bay has wholly stopped the drifting of ice from that water through the Kill van Kull.

M. de Molon has obtained from the peats of Brittany, by means of suitable reagents, benzine, paraffine, fatty oils, phenols, resinous matters, acetic acid, and seventeen or eighteen per cent. of a waxy substance analogous to the resins, which in distillation furnishes enough paraffine to make the preparation profitable. The same peat affords an illuminating gas superior to that obtained from coal, and one third cheaper.

M. Bourdon has devised a system of drainage by means of which the underground atmosphere of a whole vineyard may be uniformly and effectively impregnated with sulphuret of carbon for the prevention of phylloxera. The expense of setting the system in operation is great, but after this a saving may be realized of four fifths of the material it has hitherto been necessary to use.

M. F. Zurcher has contributed a new element to the discussion of the question of the relation between the number of sun-spots and the rainfall. He has made a comparison of the maximum heights of the inundation of the Nile and of the numbers of sun-spots as indicated by Wolf, for forty-five years, from 1825 to 1870. The curves representing the two values show a parallelism throughout that is remarkable, if nothing more.

M. Gaston Bonnier has found, from investigations recently made in Austria and Hungary, that the intensity in the color of flowers of the same species increases with the altitude, though in a less marked degree than the deepening of color that corresponds with a greater height of latitude. The fact has been made clear to him in many cases by the comparison of colors in two, three, four, and sometimes five places of increasing altitude, in which the hues showed a gradation of intensity. A microscopical examination disclosed that the change was not occasioned by a new disposition of the coloring matter, but by an increase in the number of grains of pigment on a given surface.



JULIUS ADOLPH STOCKHARDT.

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PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

CLOTHING.

"No better traveling habit than *hardy habits*."—Sir Samuel Baker.

THE capacity of our ancestors to accommodate themselves to every climate depended not only on their physiological faculty of adaptation, but also on their skill in protecting themselves by artificial means from the inclemency of the higher latitudes. Houses and clothes are a blessing if they answer this purpose by a close imitation of Nature's own plan in sheltering her children from atmospheric vicissitudes; but in degree as they deviate from that plan their hygienic disadvantages balance, or even outweigh, the gain in other respects. A swallow's nest protects her brood from cold and rain without debarring them from the fresh air; a human domicile, too, should combine comfort with the advantage of perfect ventilation; and our clothes, like the fur of a squirrel or the feather-mantle of a hawk, should keep us warm and dry without interfering with the cutaneous excretions and the free movement of our limbs.

Measured by these standards, the winter dress of an American schoolboy is nearly the best, the summer dress of the average American, French, and German nursling about the worst that could possibly be devised. At an age when the rapid development of the whole organism requires the utmost freedom of movement, our children are kept in the fetters of garments that check the activity of the body in every way: swaddling-clothes, undershirts, overshirts, neck-wrappers, trailing gowns, garnitures, flounces, and shawls reduce the helpless *homunculus* to a bundle of dry-goods, unable to move or turn, incapable of relieving or intimating its uneasiness in any way save by the

use of its squealing apparatus, and consequently squealing violently from morning till night. Out-doors, in the baby-carriage, "cold draughts" have to be guarded against, and a load of extra wrappers completely counteract the benefit of the fresh air; faint with nausea and suffocating heat the little mummy lies motionless on its back, resplendent in its white surplice, a fit candidate for the honors of a life whose every movement of a natural impulse will be suppressed as a revival of barbarism and an insurrection against the statutes of an orthodox community. Hence, in a great degree, the disproportionate mortality, in all northern countries of Christendom, among infants under two years. In Spanish America, where infantile diseases are as rare as in Hindostan, babies of all classes and all sizes toddle about *naked*, nearly the year round; and the Indians of Tamaulipas, between Tampico and Matamoras, raise an astonishing number of brown bantlings who are never troubled with clothes till they are big enough to carry garden-stuff to a city where the police enforces the apron regulation.

But Mrs. Grundy—a person's pinafore—and the carpet? Well, get a lot of short linen hose, rather loose about the hips and tied around the waist or buttoned to the skirts of a short frock. Change them as often as you like. Wholesale they could be made for a dollar and washed for a quarter a dozen. Out-doors add a pair of stockings with canvas soles, and perhaps little rubber boots on wet days, but no cap or shawl before October, and under no circumstances any swaddles or baby night-gowns. Let us get rid of the "draught" superstition; catarrhs are not taken by any creature of the open air, not by the fisherman's boy, paddling around in the surf and sitting barefooted in a wet canoe or bareheaded on the windward cliffs, but by the cachectic cadets of the tenement-barracks, where the same air is breathed and rebreathed by the diseased lungs of a regiment of voluntary prisoners.*

After the first frost, a cap with ear-flaps, double stockings, and mittens out-doors can do no harm. A warm shirt and two quilt-blankets will be enough in all but the coldest nights, and (if I had not seen the thing done I should commit an outrage on common-sense by thinking it necessary to mention it) the face of a sleeping child should never be covered with a shawl, nor—when flies are very troublesome—with anything thicker than the lightest gauze handkerchief. "A great store of clothes," says Lord Bacon, "either upon the bed or the back, relaxes the body"; and every observant parent must have noticed that school-children complain a hundred times of being overdressed for once that they ask for additional or warmer clothing. Indeed, only dire habit can reconcile us to the mass of trappings and wrappings

* "I shall not attempt to explain why 'damp clothes' occasion colds rather than wet ones, because I doubt the fact. I imagine that neither the one nor the other contributes to this effect, and that the causes of colds are totally independent of wet and even of cold."—(Ben Franklin's "Essays," p. 216.)

which fashion and effeminacy load us with. Five hundred millions of our fellow-men wear scarcely any clothing—not in Africa and Southern Asia only, but in cold Patagonia and the by no means genial latitudes of the Norfolk Islands. The mantle of the Roman peasant was laid aside in cold weather and generally at the beginning of the day's work. The sculptures of Rome and Greece abound with the representations of nude hunters, shepherds, and artisans. On the friezes of Pompey and the countless vases and entablatures of the Museo Borbonico and the Vatican collection, children, almost without any exception, appear *in naturalibus*. The very word *gymnasium* was derived from γυμνόσ, *naked*; and there is every reason to believe that the *toga virilis*, like the *toga prætexta*, was worn only on state occasions. Henry's "History of Great Britain" (vol. i, pp. 468, 469) leaves hardly any doubt that the ancient Britons, Picts, and Scots were either wholly or almost naked, "unless their custom of painting their bodies can be considered as clothing." Nor did the south Britons and Romans go naked from poverty, like Darwin's Firelanders. They had clothes, but they reserved them for emergencies, and, though our advanced notions of decency and cleanliness might not permit us to emulate their example, I suspect that, from May to November, the lightest suit of clothes is, from an hygienic standpoint, about the best. The body breathes through the pores as well as through the lungs, and heavy garments obstruct the cutaneous exhalations quite as much as the atmosphere of an overheated room impedes the process of respiration, and it has been found by actual experiments that the weight of a mantle or heavy coat with woolen shirts and other underwear diminishes the respiratory capacity of the lungs from twenty to twenty-five per cent.—(Coale's "Hints on Health," p. 104.)

Besides, it seems that fresh air exercises on the human skin a certain tonic influence, of which the wearer of thick woolen garments deprives his body. Benjamin Franklin proposed to prevent colds, and even small-pox, by *air-baths*, and found that he could relieve insomnia by simply removing the bedclothes for a couple of minutes. "I rise early almost every morning," says he, "and sit in my chamber without any clothes whatever, half an hour or an hour, according to the season, either reading or writing. This practice is not the least painful but, on the contrary, agreeable, and if I return to bed afterward, before I dress myself, as it sometimes happens, I make a supplement to my night's rest of one or two hours of the most pleasing sleep that can be imagined."—("*A New Mode of Bathing*," Franklin's "Essays," p. 215.)

Nor should we forget the incidental advantages of hardy habits, their invigorating influence on the constitution in general and on the digestive system in particular, nor the fact that effeminacy defeats its own object and exposes its slaves to sufferings unknown to the sons of the wilderness. He who restricts himself to a minimum of clothes in

summer-time will find an extra shirt or a plaid and a pair of mittens a sufficient protection from almost any weather. The Indians of the Tehuantepec highlands, who work the year round in a breech-clout and a palmetto hat, ascend the icy summit regions of the Sierra Madre with a threadbare blanket as their only cover from cold winds and night frosts; and our own red-skins prefer an old-buffalo robe to the best tight-fitting garments, and invariably tear the seams of the store-clothes they buy at the post-agencies—to make them "lighter," ventilate them, as it were. Nay, the post-trader of Fort Richardson, on the upper Brazos, assured me that his Kiowa customers never bought a suit of clothes without cutting the seat out of the pantaloons and slitting the coats from the armpits down to the skirts!

If an out-door laborer leaves a warm house on a cold morning, the first contact with the open air is anything but agreeable, but after half an hour's exercise the body warms up from within, and this animal caloric can make a heavy suit of clothes as oppressive in winter as in midsummer; the gaseous excretions of the skin, after saturating the confined air, are condensed and thus effectually checked—the body has to forego the benefits of cutaneous respiration. And herein consists the difference between our artificial fleece and the hairy coat of a wild beast: fur and wool retain the animal warmth but emit the cutaneous vapors; a close woven coat stops both. The process of tanning, too, stops the pores of the fur-skin, and I have often wondered why our dress-reformers have never tried to construct a fur coat on the brush-maker's plan—fastening the hair in little bunches on some strong, net-like texture. By spreading outward, the hair would present the even surface of the natural fur, and make such a porous brush coat nearly as warm as a common pelisse. Thus far the same end has been most nearly attained by the triple blouse of the Havre 'longshoremen—three linen jackets; the first and third as smooth as a shirt, but the middle one *ruffled*, i. e., gathered up in a series of open plaits like a mediæval lace collar. This arrangement prevents a "tight fit," and leaves a considerable space on both sides of the middle blouse, and, air being a bad conductor, the three blouses, weighing about three pounds apiece, are actually warmer than a twelve-pound overcoat of thick broadcloth, but fitting the back like the cover of a pin-cushion. On going to work, the *porte-faix* removes one or two of his blouses, according to the state of the weather, as the American schoolboy takes off his comforter and unbuttons his jacket before going in for a snow-ball fight.

A jacket or a short blouse is out and out more sensible than our cumbersome overcoats or the unspeakable tangle-work of frippery and flounces, cross-and-lengthwise wrappings, and intricate fastenings that still form the winter dress of a fashionable lady. The women of Scandinavia and New England (Jenny Lind, Mrs. Everett, Dr. Mary Safford-Blake, etc.) can claim the honor of having initiated the oppo-

sition movement that bids fair to abate the grievance in the course of another generation or two, having already exploded the chief outrages on hygienic and artistic common-sense—corsets and the crinoline. Mrs. Abba G. Woolson's "Dress Reform" should be the sartorial text-book of every girl's mother.

The Turks and Hollanders, though differing so widely in their general mode of life, agree in preferring warm clothes to heated rooms, and when the in-door atmosphere can be made tolerable only by air-tight window-sashes and glowing stoves, it is a curious question whether a warmer dress would not, on the whole, be the lesser evil. It would save fuel, sick-headaches, and constipation, and by adding or removing an extra blouse, *à la Normandie*, the several occupants of a moderately warmed room might exactly adapt the temperature to their individual feelings. A German author, who admits hardly any excuse for excluding the fresh air from a sitting-room, proposes an ingenious remedy for *cold hands*—the only cogent objection to an open study-window: a box writing-desk, namely, with a double lid, the writing-board resting on top of a box full of hot sand, that can be warmed in a common baking-pan and warranted to retain its heat for five or six hours. A cold garret library was Goethe's favorite refuge from sick-headaches; and the Chevalier Edelkranz reminds his fur-loving countrymen that, when the difference of temperature between the external air and that within-doors is inconsiderable, it would be useful to "put on an extra coat on *returning* home, instead of doing it when going out, since the exercise in the open air produces the necessary degree of warmth, which, in the chamber, in a sedentary state, can only be supplied by additional clothing."

In our climate, however, there are days when a child of the Caucasian race has urgent need of all the overcoats his shoulders can support, and the natives of northern Michigan have taught their Saxon neighbors some useful lessons in the art of surviving a Lake Superior snow-storm. Experience has made them eschew our common head-gear; they wear "Mackinaw hoods," a sort of monk's cowl, buttoned to the mantle-collar and covering every part of the face but the eyes and a small space between the mouth and the nostrils; double woolen mittens, reaching half-way up to the elbow; baggy trousers, fastened around the ankle, and shoes that admit three or four pairs of worsted stockings. Their particular care seems to be to protect the neck, hands, and feet; and it might, indeed, be accepted as a general rule that the parts of the body farthest from the heart are most liable to suffer from the effects of a low temperature. All extremities—toes, fingers, nose, and ears—are especially apt to get frost-bitten, but marching against a cold wind also produces a peculiarly uncomfortable sensation about the *neck*, and I can not help thinking that there is something wrong about our fashion of cropping our boys like criminals. A good head of hair may be something more than an ornamental

appendage, and Nature seems to have taken especial care to protect the nape of the neck in a great number of different animals. It is certainly a suggestive circumstance that fomenting the space between the shoulders exerts an assuaging effect on various affections of the respiratory organs; and, if I had the care of a boy with an hereditary disposition to a pulmonary disease, I should feel strongly tempted to defy fashion, and let him wear his hair *à la Guido*—about a foot long.

The canal-laborers of Sault Ste. Marie wear double hoods, and on many days have to stuff them with wool to save their ears; but, in the more populous part of America, such days are a rare exception, and south of the lower lakes the average schoolboy will prefer to rough it with a tippet shawl or a common cap with a pair of ear-flaps. In regard to the utility of woolen underclothes, opinions are much divided: Carl Bock recommends worsted jackets; Dr. Coale flannel undershirts and drawers, with extra breast-pads in cold weather; but the hardy Scandinavians, Russians, and French Canadians, as well as the great majority of our German population, still stick to coarse linen next the skin, and use woolen pectorals only as counter-irritants in rheumatic affections. Persons who can not bear woolen underclothes, I would advise to try the Normandy plan of ruffled linen, which might be applied even to hoisery and drawers. Chamois-leather, too, is as warm as wool and less irritating to the skin, and has the advantage of being more durable, and withal cleanlier, than the best flannel. On stormy days, especially during the piercing northwest storms of our prairie States, few children will object to a Scotch plaid, worn like a burnoose, over head and shoulders, or a handful of wool stuffed around the socks in a pair of wide brogans.

But at the beginning of the warm season all such things ought to be thrown aside. A loose shirt, linen jacket, and short linen trowsers are the right summer dress for a healthy boy—a dalmatica and light straw hat for a healthy girl—in a country where the six warmest months approach the isotherms of southern Spain. No wadded coats, no drawers, and, in the name of reason, no flannels, nor shoes and stockings, unless the mud is very deep, or the road to school recently macadamized. The long-lived races of Eastern Europe would laugh at the idea that the constitution of a normal human being could be endangered by an April shower, or that in the dog-days "health and decency" require a woolen cuticle from neck to foot. Have dogmas and hearsays entirely closed our senses to the language of instinct, to the meaning of the discomfort, the distracting uneasiness under the burden of a load of calorific covers and bandages, while every pore of our skin cries out for relief, for the cooling influence of the free open air? Keep your children under lock and key, lest the sun should spoil their complexion or their morals, let them pass their days in an underground dungeon like Kaspar Hauser, but do not load

them with woolen trappings at a time when even a linen robe becomes a Nessus-shirt. There is a story of a glutton being cured by a friend who persuaded him to eat and drink nothing for twenty-four hours without putting an equivalent in quantity and quality into an earthen crock, and the next day made him inspect the *collectanea ;* and on the same principle a person of common-sense might perhaps be redeemed from the slavery of the dress-mania, by making him wrap up his complete suit of traps and weigh the bundle : he would find that the summer dress of a fashionable gentleman outweighs the winter coat of the most hirsute brute of the wilderness. A grizzly bear, shorn to the skin, would yield about ten pounds of hair and wool ; but a dandy's accoutrements—flannel undershirt, drawers, shoes, stockings, starched overshirt, waistcoat, cravat, black dress-coat, and pantaloons—would weigh at least fourteen pounds. Habit mitigates the evil, though there are times when the martyrs of fashion suffer more in a single hour than a ragged Comanche in the coldest winter week ; but, for boys and young girls, calorific food and woolen clothes certainly make the sunniest days the saddest in the year.

The vicissitudes of the weather? It is worth a journey to Trieste to see the youngsters of the suburbs enjoy their evenings on the Capo Liddo, the sandy headland between the Pola pike-road and the harbor fortifications : four or five hundred half-wild boys, splashing in the surf, throwing stones, wrestling, or chasing each other along the shore, all shouting and cheering, merry as carnivallers, though there is not a pair of shoes or a dozen hats in the crowd. Swift-footed, lithe, and indefatigable, they are the very picture of careless health ; you can see them at play almost every evening, even in winter, when the *Tramontane* raises the snow-drifts of the Karst. They laugh at summer showers ; their linen jackets will dry before they get home. Sunshine makes them a holiday ; but let your well-dressed New York or Paris schoolboy join in their sports, and examine his clothes after an hour or two, and see if perspiration has not made his undershirts as wet as any rain could make his jacket.

Decency? Are the gambols of a barefoot boy more unseemly than the contortions of a sunstruck alderman in his holiday dress? Can ethics or æsthetics be promoted by the imprecations of a sleepless victim of flannel night-shirts and closed bedroom windows? If daily misery can spoil the temper of a saint, the ladies of the American Dress-Reform are working in the interest of charity and good-humor by removing a chief incentive to the opposite sentiments, for the aggravations of Tantalus must have been trifling compared with those of an American schoolgirl *à la mode*, at the thought of a mountain meadow to run on with naked feet or a shady brook to pick pebbles from with bared arms. Pocahontas, indeed, had no need to envy the "fair maids in the land of her lover," if the fair ones had to wear the twenty-three distinct pieces of dry-goods which, according to a cor-

respondent of Virchow's "Jahresberichte," constitute the summer dress of the average girl of the period. The blind submission to such demands of fashion can be explained only by a long subjection of human reason to authority, together with that ridiculous *dread of nudity* which forms a characteristic feature of all anti-natural religions. According to the ethics of the Hebrew-Buddhistic moralists, all *naturalia sunt turpia;* the body is the arch-enemy of the soul, and must be hidden, lest the children of the Church might be reminded of their relationship to the despised children of Nature. Boys and girls have no vote in such matters, or they would consent to turn night into day for the sake of getting a little exercise without the dire alternative of sweating to death or awakening the anathemas of Mrs. Grundy. The misery reaches its climax in June, when the warm weather begins before the vacations; and in midsummer a person with humane instincts would rather make a wide *détour* than pass a town school or a cotton-factory and witness the triumph of our pious civilization—the daily and intolerable torture of thousands of helpless children to please an Old Hypocrites' Christian Association of priests and prudes!

As houses have been called exterior garments, a heavy suit of clothes might be called a portable house—a protective barrier between the skin and the cold air; but in warm weather the most effectual device for diminishing the benefit of out-door exercise. Between May and October man has to wear clothes enough to keep the flies and gnats from troubling him: a pair of linen trowsers, a shirt, and a light neckerchief—whatsoever is more than these is of evil. The best head-dress for summer is our natural hair; the next best a light straw hat, with a perforated crown. Hats and caps, as a protection from the vicissitudes of the atmosphere, are a comparatively recent invention. The Syrians, Greeks, Romans, Normans, and Visigoths wore helmets in war, but went uncovered in time of peace, in the coldest and most stormy seasons; the Gauls and Egyptians always went bareheaded, even into battle, and, a hundred years after the conquest of Egypt by Cambyses (B. C. 525), the sands of Pelusium still covered the well-preserved skulls of the native warriors, while those of the turbaned Persians had crumbled to the jawbones. The Emperor Hadrian traveled bareheaded from the icy Alps to the borders of Mesopotamia; the founders of several monastic orders interdicted all coverings for the head; during the reign of Henry VIII, boys and young men generally went with the head bare, and to the preservation of this old Saxon custom Sir John Sinclair* ascribes the remarkable health of the orphans of Queen's Hospital. The human skull is naturally better protected than that of any other warm-blooded animal, so that there seems little need of adding an artificial covering; and, as Dr. Adair observes, the most neglected children, street Arabs and young gypsies, are least

* "Code of Health and Longevity," p. 298.

liable to diseases, chiefly because they are not guarded from the access of fresh air by too many garments (Adair's "Medical Cautions," p. 389). It is also well known that baldness is the effect of effeminate habits as often as of dissipation ; and yet there are parents who think it highly dangerous to let a boy go out bareheaded even in May or September. The trouble is, that so many of our latter-day health codes are framed by men who mistake the exigencies of their own decrepitude for the normal condition of mankind. Thousands of North American mothers get their hygienic oracles from the household notes of some orthodox weekly, where the Rev. Falstaff Tartuffe assures them—from personal experience—that raw apples are indigestible, and that rheumatism can be prevented only by nightcaps and woolen undershirts.

Girls, it seems, have to pass through a millinery climacteric, as their brothers through a wild-oats period ; but even during that interregnum of reason the instinct of self-preservation would assert its supremacy if the health laws of physiology and their antagonism to certain fashions were more generally understood. Claude Bernard speaks of a French philanthropist who proposed to offer a prize for the most tasteful female dress, manufactured from the cheapest materials ; and, if the votaries of the Graces would consent to a reform in the shape and stuff of their garments, we could well afford to indulge them in chromatics and a flounce or two, for there is no reason to afflict them with Quaker-drab, if more cheerful colors are as cheap. As long as they avoid excesses in the quantity and form of their dress, and restrict themselves to four dimes' worth of vanities per month, we need not grudge them a display of their taste in the selection of pretty patterns ; let them radiate in all the colors of the rainbow and all the gems of the "Chicago Prize-Package Company." *Veniunt a veste sagittæ*—the dress problem has always employed the leisure of gossips and Doctors' Commons, especially in cities, and more especially in the wealthy and indolent cities of the Old World. There is a legend of a New England virgin fainting at the mention of "undressed lumber," but that tradition must be of Eastern origin. The dry-goods worship is carried nowhere further than where children are treated like dolls and women like children, unfit to be intrusted with any more important business. The "organ of ornamentativeness," or fashion-mania, may, after all, not be an innate instinct of the female mind. Madame de Staël and Mrs. Lewes at least deny it, and, if they are right, an enlarged sphere of activity will by-and-by help their sisters to outgrow that bias. In the mean while, the best palliative is a liberal education, besides a zealous propaganda of the two chief theses of the *dress reform :* wider jackets and shorter under-garments ; no trailing dresses, keeping the feet wet and impeding locomotion ; no stays, corsets, and strait-jacket bodices.

Next to the regulation dress of the Turner hall, the present style

of the United States infantry uniform is about the most sensible that could be devised with regard to sanitary advantages, and nearly so in respect to good taste, if Thorwaldsen's dictum holds good, that the most becoming garments are those which adapt themselves to the natural outlines of the human form. A jacket should be loose, with wide but rather short sleeves, loose trousers, no waistcoat or drawers in the summer season; for small boys, short trousers without pockets, but with broad leather braids along the seams. The comparative advantages of waistbands or braces have been frequently controverted; at best it is only a question of choosing the lesser evil. A tight belt is almost as injurious as a corset, while non-elastic suspenders may interfere with the functions of the respiratory organs, and even occasion stooping. For boys and slender-built men, with well-developed hips, an elastic waistband is, on the whole, preferable; corpulent persons can not dispense with braces, for the plan of buttoning the breeches to the jacket or waistband would amount to the same, by making the shoulders support the weight of the lower garments. Tight breeches have, fortunately, gone out of fashion; likewise tight kid-gloves, which were once *de rigueur* on every public promenade.

But we all sin against our feet; not one white man in ten thousand wears shoes that are not more or less of a hindrance in walking, and often a source of wretched discomfort. In the United States, England, and Central Europe, it is wholly impossible to find a ready-made pair of shoes to fit a normal human foot; they are all too tight in proportion to their length, every pair of them, even the United States army shoes and the English "fast-walking brogans." Heels are nonsense; there is no excrescence on the sole of a well-formed human being. A man can walk faster, more easily, and more gracefully, with level shoes, with soles shaped like those of a slipper or an Indian moccasin. An easy shoe should be heelless; the upper leather soft and pliable; the sole of a No. 9 shoe at least four inches wide. But you can not persuade a shoemaker to commit such heresies against the tenets of his craft. Dio Lewis recommends paper patterns, corresponding to the exact shape of the natural sole, but it is all in vain; a compromise between reason and dogma is the best you can attain by such means. The only practicable plan is to get one pair of shoes made under your personal supervision, and then stipulate for the necessary number of precise *fac-similes*. The disciple of St. Crispin shrinks from the guilt of the original sin, but connives at a copy; a precedent will reconcile his conscience.

For children there is a shorter expedient: let them go barefoot, at least in-doors and all summer; it will make them hardier and healthier. Abernethy, Schrodt, Dr. Adair, Jean Jacques Rousseau, and Claude Bernard, agree on this point; Dr. Cadogan thinks shoes and stockings wholly useless, and John G. Whittier seems to share his opinion that a barefoot boy is the happiest representative of the human species. "I

can see no reason why my pupil should always have a piece of ox-hide under his foot," says the author of "Emile." . . . "Let him run barefoot wherever he pleases. . . . Far from growling about it, I shall imitate his example." *

Refusing to buy tight shoes might bring easy ones into fashion; but boys are better off without them, especially in the years of rapid growth, when their measure changes from month to month, for too wide shoes are as uncomfortable as tight ones. Out-doors, children's stockings are almost sure to get wet, and keep the feet clammy and cold; while a young gypsy or a Scotchman, inured to wind and weather, treads with his bare feet the swampiest valleys and the roughest hill-roads without the least discomfort. Nature produces a better sole-leather than any shoemaker; the tegument of a raccoon's foot or a monkey's hind-hand can give us an idea of the marvels of her workmanship. The sole of a plantigrade animal is not hard; on the contrary, quite pliable and soft to the touch, but withal *tougher* than any caoutchouc, impervious alike to water, sand, and thorns. A camel, too, has a foot of that sort—pads that resist the burning gravel of the desert for years, where a horse's hoof would wear out in a few weeks; for the same reason that a "sand-blast" destroys tanned sole-leather and horn, but hardly affects the elastic skin of the human hand. Millions of unshod Hindoos, negroes, and South American savages, brave the jungles of the tropical virgin woods; and in Nicaragua I saw two Indian mail-carriers *trot* barefoot over the lava-beds of Amilpas, over fields of obsidian and scoria, where a dandy in patent-leather gaiters would have feared to tread. Three or four seasons of barefoot rambles over the fields and hills will develop such soles—natural shoe-leather that improves from year to year, till it can be warranted to protect the wearer against the roughest roads, and, as the experience of our half-wild frontiersmen attests, also against colds and rheumatism. A mere moccasin secures such hardy feet against frost-bites; for here, too, the rule holds good that those who keep themselves too warm in the summer season deprive themselves of the advantage to be derived from additional clothing in cold weather and in old age.

Herr Teufelsdröckh devoted a voluminous work to the "Philosophy of Clothing," but the practical part of the science may be summed up in a few words. Our dress ought to be adapted to the changes of the seasons, and should be in quality durable, cleanly, and, above all, easy; in quantity, the least amount compatible with decency and comfort.

* "Pourquoi faut-il que mon élève soit forcé d'avoir toujours sous les pieds une peau de bœuf? Quel mal y aurait-il que la sienne propre pût au besoin lui servir de semelle? Il est clair qu'en cette partie la delicatesse de la peau ne peut jamais être utile à rien et peut souvent beaucoup nuire. Que Émile coure les matins à pieds nus, en toute saison, par le chambre, par l'escalier, par le jardin; loin de l'en grondir je l'imitirai."—(Rousseau: "Émile, ou de L'éducation," p. 143.)

ON FRUITS AND SEEDS.

By Sir JOHN LUBBOCK, F. R. S.

OUR eloquent countryman, Mr. Ruskin, commences his work on "Flowers" by a somewhat severe criticism of his predecessors. He reproduces a page from a valuable but somewhat antiquated work, "Curtis's Magazine," which he alleges to be "characteristic of botanical books and botanical science, not to say all science," and complains bitterly that it is a string of names and technical terms. No doubt that unfortunate page does contain a list of synonyms and long words. But, in order to identify a plant, you must have synonyms and technical terms, just as to learn a language you must have a dictionary. To complain of this would be to resemble the man who said that Johnson's "Dictionary" was dry and disjointed reading. But no one would attempt to judge the literature of a country by reading a dictionary. So also we can not estimate the interest of a science by reading technical descriptions. On the other hand, it is impossible to give a satisfactory description of an animal or plant except in strict technical language. Let me reproduce a description which Mr. Ruskin has given of the swallow, and which, indeed, he says in his lecture on that bird, is the only true description that could be given. His lecture was delivered before the University of Oxford, and is, I need hardly say, most interesting.

Now, how does he describe a swallow? "You can," he says, "only rightly describe the bird by the resemblances and images of what it seems to have changed from, then adding the fantastic and beautiful contrast of the unimaginable change. It is an owl that has been trained by the Graces. It is a bat that loves the morning light. It is the aërial reflection of a dolphin. It is the tender domestication of a trout." That is, no doubt, very poetical, but it would be absolutely useless as a scientific description, and, I must confess, would never have suggested, to me at least, the idea of a swallow.

But, though technical terms are very necessary in science, I shall endeavor, as far as I can, to avoid them here. As, however, it will be impossible for me to do so altogether, I will do my best at the commencement to make them as clear as possible, and I must therefore ask those who have already looked into the subject to pardon me if, for a few moments, I go into very elementary facts. In order to understand the structure of the seed, we must commence with the flower, to which the seed owes its origin. Now, if you take such a flower as, say, a geranium, you will find that it consists of the following parts: firstly, there is a whorl of green leaves, known as the sepals, and together forming the calyx; secondly, a whorl of colored leaves, or petals, generally forming the most conspicuous part of the flower, and called the

corolla; thirdly, a whorl of organs, more or less like pins, which are called stamens; and in the heads, or anthers, of which the pollen is produced. These anthers are in reality, as Goethe showed, modified leaves; in the so-called double flowers, as, for instance, in our garden roses, they are developed into colored leaves like those of the corolla, and monstrous flowers are not unfrequently met with in which the stamens are green leaves, more or less resembling the ordinary leaves of the plant. Lastly, in the center of the flower is the pistil, which also is theoretically to be considered as constituted of one or more leaves, each of which is folded on itself and called a carpel. Sometimes there is only one carpel. Generally the carpels have so completely lost the appearance of leaves that this explanation of their true nature requires a considerable amount of faith. The base of the pistil is the ovary, composed, as I have just mentioned, of one or more carpels, in which the seeds are developed. I need hardly say that many so-called seeds are really fruits; that is to say, they are seeds with more or less complex envelopes.

We all know that seeds and fruits differ greatly in different species. Some are large, some small; some are sweet, some bitter; some are brightly colored; some are good to eat, some poisonous, some spherical, some winged, some covered with bristles, some with hairs, some are smooth, some very sticky.

We may be sure that there are good reasons for these differences. In the case of flowers much light has been thrown on their various interesting peculiarities by the researches of Sprengel, Darwin, Müller, and other naturalists. As regards seeds also, besides Gärtner's great work, Hildebrand, Krause, Steinbrinck, Kerner, Grant Allen, Wallace, Darwin, and others, have published valuable researches, especially with reference to the hairs and hooks with which so many seeds are provided, and the other means of dispersion they possess. Nobbe also has contributed an important work on seeds, principally from an agricultural point of view, but the subject as a whole offers a most promising field for investigation. It is rather with a view of suggesting this branch of science to you, than of attempting to supply the want myself, that I now propose to call your attention to it. In doing so I must, in the first place, express my acknowledgments to Mr. Baker, Mr. Carruthers, Mr. Hemsley, and especially to Mr. Thiselton Dyer and Sir Joseph Hooker, for their kind and most valuable assistance.

It is said that one of our best botanists once observed to another that he never could understand what was the use of the teeth on the capsules of mosses. "Oh," replied his friend, "I see no difficulty in that, because, if it were not for the teeth, how could we distinguish the species?"

We may, however, no doubt, safely consider that the peculiarities of seeds have reference to the plant itself, and not to the convenience of botanists.

In the first place, then, during growth, seeds in many cases require protection. This is especially the case with those of an albuminous character. It is curious that so many of those which are luscious when ripe, as the peach, strawberry, cherry, apple, etc., are stringy and almost inedible till ripe. Moreover, in these cases, the fleshy portion is not the seed itself, but only the envelope, so that even if the sweet part is eaten the seed itself remains uninjured.

On the other hand, such seeds as the hazel, beech, Spanish chestnut, and innumerable others, are protected by a thick, impervious shell, which is especially developed in many *Proteaceæ*, the Brazil-nut, the so-called monkey-pot, the cocoanut, and other palms.

In other cases the envelopes protect the seeds, not only by their thickness and toughness, but also by their bitter taste, as, for instance, in the walnut. The genus *Mucuna*, one of the *Leguminosæ*, is remarkable in having the pods covered with stinging hairs.

In many cases the calyx, which is closed when the flower is in bud, opens when the flower expands, and then after the petals have fallen closes again until the seeds are ripe, when it opens for the second time. This is, for instance, the case with the common herb-robert (*Geranium Robertianum*). In *Atractylis cancellata*, a South European plant, allied to the thistles, the outer envelopes form an exquisite little cage. Another case, perhaps, is that of *Nigella*, the "Devil-in-a-bush," or, as it is sometimes more prettily called, "Love-in-a-mist," of old English gardens.

Again, the protection of the seed is in many cases attained by curious movements of the plant itself. In fact, plants move much more than is generally supposed. So far from being motionless, they may almost be said to be in perpetual movement, though the changes of position are generally so slow that they do not attract attention. This is not, however, always the case. We are all familiar with the sensitive-plant, which droops its leaves when touched. Another species (*Averrhoa bilimbi*) has leaves like those of an acacia, and all day the leaflets go slowly up and down. *Desmodium gyrans*, a sort of pea living in India, has trifoliate leaves, the lateral leaflets being small and narrow; and these leaflets, as was first observed by Lady Monson, are perpetually moving round and round, whence the specific name *gyrans*. In these two cases the object of the movement is quite unknown to us. In *Dionæa*, on the other hand, the leaves form a regular fly-trap. Directly an insect alights on them they shut up with a snap.

In a great many cases leaves are said to sleep; that is to say, at the approach of night they change their position, and sometimes fold themselves up, thus presenting a smaller surface for radiation, and being in consequence less exposed to cold. Mr. Darwin has proved experimentally that leaves which were prevented from moving suffered more from cold than those which were allowed to assume their natural position. He has observed with reference to one plant, *Maranta arundi-*

nacea, the arrow-root, a West Indian species allied to *Canna*, that if the plant has had a severe shock it can not get to sleep for the next two or three nights.

The sleep of flowers is also probably a case of the same kind, though, as I have elsewhere attempted to show, it has now, I believe, special reference to the visits of insects; those flowers which are fertilized by bees, butterflies, and other day insects, sleep by night, if at all; while those which are dependent on moths rouse themselves toward evening, as already mentioned, and sleep by day. These motions, indeed, have but an indirect reference to our present subject. On the other hand, in the dandelion (*Leontodon*), the flower-stalk is upright while the flower is expanded, a period which lasts for three or four days; it then lowers itself and lies close to the ground for about twelve days, while the fruits are ripening, and then rises again when they are mature. In the *Cyclamen* the stalk curls itself up into a beautiful spiral after the flower has faded.

The flower of the little *Linaria* of our walls (*L. cymbalaria*) pushes out into the light and sunshine, but as soon as it is fertilized it turns round and endeavors to find some hole or cranny in which it may remain safely ensconced until the seed is ripe.

In some water-plants the flower expands at the surface, but after it is faded retreats again to the bottom. This is the case, for instance, with the water-lilies, some species of the *Potamogeton* (*Trapa natans*). In *Valisneria*, again, the female flowers (Fig. 1, *a*) are borne on long stalks, which reach to the surface of the water, on which the flowers float. The male flowers (Fig. 1, *b*), on the contrary, have short, straight stalks, from which, when mature, the pollen (Fig. 1, *c*) detaches itself, rises to the surface, and, floating freely on it, is wafted about, so that it comes in contact with the female flowers. After fertilization, however, the long stalk coils up spirally, and thus carries the ovary down to the bottom, where the seeds can ripen in greater safety.

The next points to which I will direct your attention are the means of dispersion possessed by many seeds. Farmers have found by experience that it is not desirable to grow the same crop in the same field year after year, because the soil becomes more or less exhausted. In this respect, therefore, the powers of dispersion possessed by many seeds are a great advantage to the species. Moreover, they are also advantageous in giving the seed a chance of germinating in new localities suitable to the requirements of the species. Thus a common European species, *Xanthium spinosum*, has rapidly spread over the whole of South Africa, the seeds being carried in the wool of sheep. From various considerations, however, it seems probable that in most cases the provision does not contemplate a dispersion for more than a short distance.

There are a great many cases in which plants possess powers of movement directed to the dissemination of the seed. Thus, in *Geas-*

trum hygrometricum, a kind of fungus which grows underground, the outer envelope—which is hard, tough, and hygrometric—divides, when mature, in strips from the crown to the base; these strips spread horizontally, raising the plant above its former position in the ground; on rain or damp weather supervening the strips return to their former

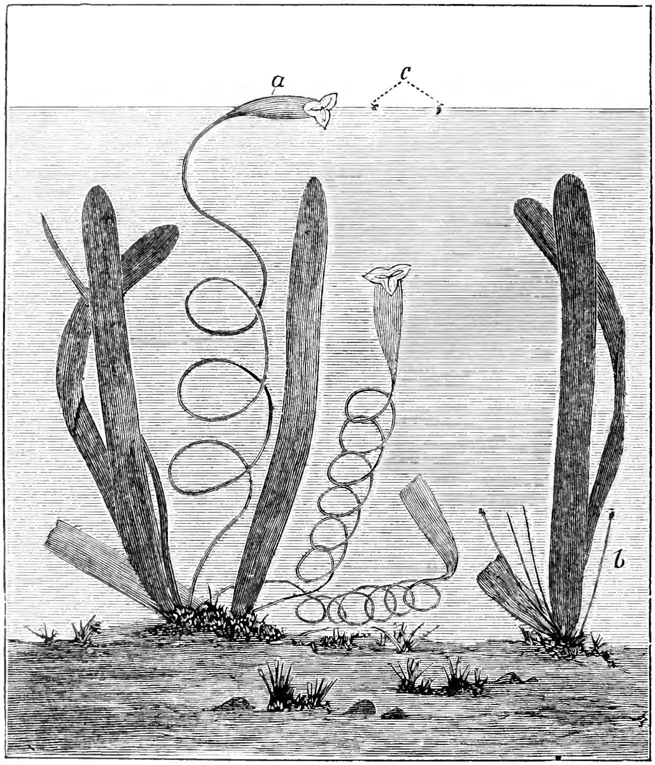


FIG. 1.—VALISNERIA SPIRALIS. *a*, female flower; *b*, male flower; *c*, floating pollen.

position; on the return of the drought this process is repeated, until the fungus reaches the surface and spreads out there; then the membrane of the conceptacle opens and emits the spores in the form of dust.

I have already referred to the case of the common dandelion. Here the flower-stalk stands more or less upright while the flower is expanded, a period which generally lasts for three or four days. It then lowers itself, and lies more or less horizontally and concealed during the time the seeds are maturing, which in our summers occupies about twelve days. It then again rises, and, becoming almost erect, facilitates the dispersion of the seeds, or, speaking botanically, the fruits, by the wind. Some plants, as we shall see, even sow their seeds in the ground, but these cases will be referred to later on.

In other cases the plant throws its own seeds to some little distance. This is the case with the common *Cardamine hirsuta*, a little plant, I do not like to call it a weed, six or eight inches high, which comes up of itself abundantly on any vacant spot in our kitchen-gardens or shrubberies, and which much resembles that represented in Fig. 17, but without the subterranean pods *b*. The seeds are contained in a pod which consists of three parts, a central membrane, and two lateral walls. When the pod is ripe the walls are in a state of tension. The seeds are loosely attached to the central piece by short stalks. Now, when the proper moment has arrived, the outer walls are kept in place by a delicate membrane, only just strong enough to resist the tension. The least touch, for instance a puff of wind blowing the plant against a neighbor, detaches the outer wall, which suddenly rolls itself up, generally with such force as to fly from the plant, thus jerking the seeds to a distance of several feet.

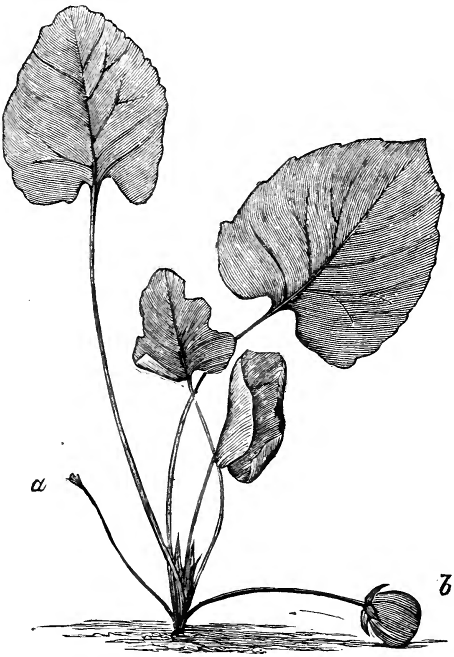


FIG. 2.—VIOLA HIRTA. *a*, young bud ; *b*, ripe seed-capsule.

In the common violets, besides the colored flowers, there are others in which the corolla is either absent or imperfectly developed. The stamens also are small, but contain pollen, though less than in the colored flowers. In the autumn large numbers of these curious flowers are produced. When very young they look like an ordinary flower-bud (Figs. 2 and 3, *a*), the central part of the flower being entirely covered by the sepals, and the whole having a triangular form. When older (Figs. 2 and 3, *b*) they look at first sight like an ordinary seed-capsule, so that the bud seems to pass into the capsule without the flower-stage. The pansy violets do not possess these interesting flowers. In the sweet-violet (*Viola odorata* and *Viola hirta*, Fig. 2) they may easily be found by searching among the leaves nestling close to the ground. It is often said, for instance by Vaucher, that the plants actually force these capsules into the ground, and thus sow their own seeds. I have not, however, found this to be the case, though, as the stalk elongates, and the point of the capsule turns downward, if the earth be loose and uneven, it will no doubt sometimes so happen.

When the seeds are fully ripe, the capsule opens by three valves and allows them to escape.

In the dog-violet (*Viola canina*, Fig. 3) the case is very different. The capsules are less fleshy, and, though pendent when young, at

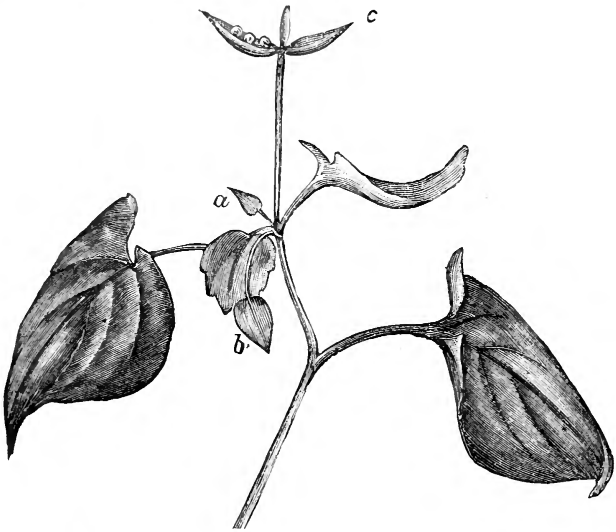


FIG. 3.—VIOLA CANINA. *a*, bud; *b*, bud more advanced; *c*, capsule open, some of the seeds are already thrown.

maturity they erect themselves (Fig. 3, *c*), stand up boldly above the rest of the plant, and open by the three equal valves (Fig. 4) resembling an inverted tripod. Each valve contains a row of three, four, or five brown, smooth, pear-shaped seeds, slightly flattened at the upper,

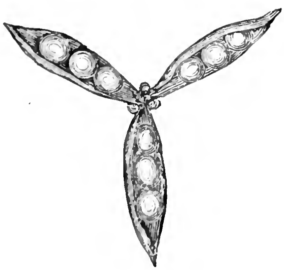


FIG. 4.

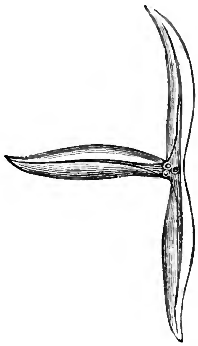


FIG. 5.—VIOLA CANINA; SEED-VESSEL AFTER EJECTING THE SEEDS.

wider end. Now the two walls of each valve, as they become drier, contract, and thus approach one another, thus tending to squeeze out the seeds. These resist some time, but at length the attachment of

the seed to its base gives way, and it is ejected several feet, this being no doubt much facilitated by its form and smoothness. I have known even a gathered specimen throw a seed nearly ten feet. Fig. 5 represents a capsule after the seeds have been ejected.

Now, we naturally ask ourselves what is the reason for this difference between the species of violets ; why do *Viola odorata* and *Viola hirta* conceal their capsules among the moss and leaves on the ground, while *Viola canina* and others raise theirs boldly above their heads, and throw the seeds to seek their fortune in the world? If this arrangement be best for *Viola canina*, why has not *Viola odorata* also adopted it? The reason is, I believe, to be found in the different mode of growth of these two species. *Viola canina* is a plant with an elongated stalk, and it is easy, therefore, for the capsule to raise itself above the grass and other low herbage among which violets grow.

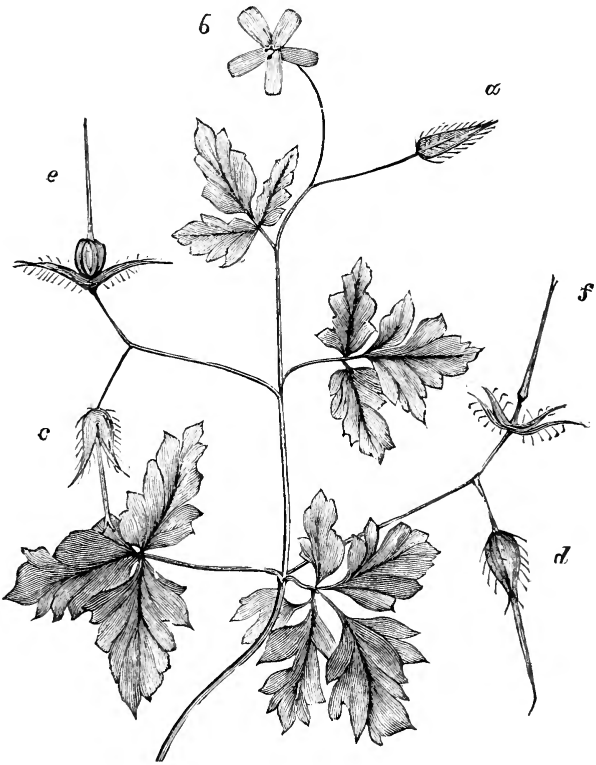


FIG. 6.—THE HERB-ROBERT (*Geranium Robertianum*,) *a*, bud ; *b*, flower ; *c*, flower after the petals have fallen ; *d*, flower with seeds nearly ripe ; *e*, flower with ripe seeds ; *f*, flower after throwing seeds.

Viola odorata and *Viola hirta*, on the contrary, have, in ordinary parlance, no stalk, and the leaves are radical, i. e., rising from the root. This is at least the case in appearance, for, botanically speaking, they rise at the end of a short stalk. Now, under these circumstances, if

the sweet violet attempted to shoot its seeds, the capsules not being sufficiently elevated, the seeds would merely strike against some neighboring leaf, and immediately fall to the ground. Hence, I think, we see that the arrangement of the capsule in each species is that most suitable to the general habit of the plant.

In the true geraniums again, as for instance in the herb-robert (Fig. 6), after the flower has faded, the central axis gradually elongates (Fig. 6, *c*, *d*). The seeds, five in number, are situated at the base of the column, each being inclosed in a capsule, which terminates upward in a rod-like portion, which at first forms part of the central axis, but gradually detaches itself. When the seeds are ripe the ovary raises itself into an upright position (Fig. 6, *e*) ; the outer layers of the rod-like termination of the seed-capsule come to be in a state of great tension, and eventually detach the rod with a jerk, and thus throw the seed some little distance. Fig. 6, *f*, represents the central rod after the seeds have been thrown. In some species, as for instance in *Geranium dissectum*, Fig. 7, the capsule-rod remains attached to the central column, and the seed only is ejected.

It will, however, be remembered that the capsule is, as already observed, a leaf folded on itself, with the edges inward, and in fact in the geranium the seed-chamber opens on its inner side. You

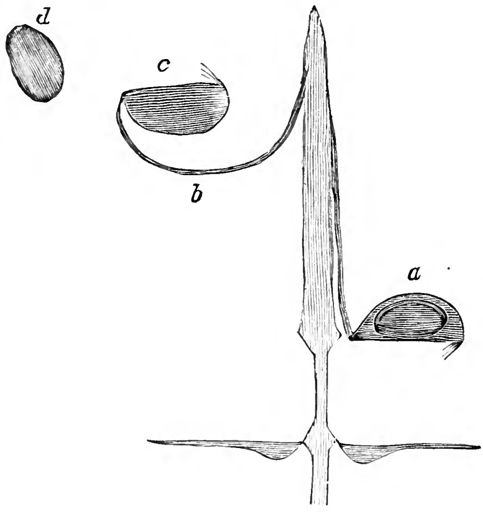


Diagram. Fig. 7.—Geranium dissectum. *a*, just before throwing seed; *b*, just after throwing seed; *c*, the capsule still attached to the rod; *d*, the seed.

will, therefore, naturally observe to me that, when the carpel bursts outward, the only effect would be that the seed would be forced against the outer wall of the carpel, and that it would not be ejected, because the opening is not on the outer but on the inner side. Your remark is perfectly just, but the difficulty has been foreseen by our

geraniums, and is overcome by them in different ways. In some species, as for instance in *Geranium dissectum*, a short time before the dehiscence, the seed-chamber places itself at right angles to the pillar (Fig. 7, *a*). The edges then separate, but they are provided with a fringe of hairs, just strong enough to retain the seed in its position, yet sufficiently elastic to allow it to escape when the carpels burst away, remaining attached, however, to the central pillar by their upper ends (Fig. 7, *c*).

In the common herb-robert (Fig. 8), and some other species, the arrangement is somewhat different. In the first place, the whole carpel springs away (Fig. 8, *b* and *c*). The seed-chamber (Fig. 8, *c*) detaches itself from the rod of the carpel (Fig. 8, *b*), and when the seed is flung away remains attached to it. Under these circumstances it is unnecessary for the chamber to raise itself from the central pillar, to which accordingly it remains close until the moment of disruption (Fig. 6, *e*). The seed-chamber is, moreover, held in place by a short tongue which projects a little way over its base; while, on the other hand, the lower end of the rod passes for a short distance between the seed-capsule and the central pillar. The seed-capsule has also near its apex a curious tuft of silky hair (Fig. 8, *c*), the use of which I will not here stop to discuss. As the result of all this complex mechanism, the seeds when ripe are flung to a distance which is surprising when we consider how small the spring is. In their natural habitat it is almost impossible to find the seeds when once thrown. I, therefore, brought some into the house and placed them on my billiard-table. They were thrown from one end completely over the other, in some cases more than twenty feet.

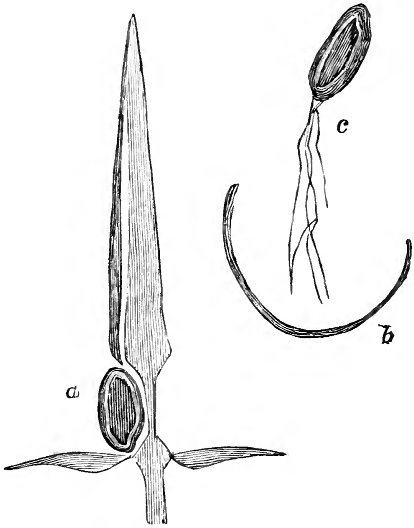


Diagram. FIG. 8.—GERANIUM ROBERTIANUM. *a*, just before throwing the seed; *b*, the red; *c*, the seed enclosed in the capsule.

Some species of vetch, again, and the common broom, throw their seeds, owing to the elasticity of the pods, which, when ripe, open suddenly with a jerk. Each valve of the pod contains a layer of woody cells, which, however, do not pass straight up the pod, but are more or less inclined to its axis (Fig. 9). Consequently, when the pod bursts it does not, as in the case of *Cardamine*, roll up like a watch-spring, but twists itself more or less like a corkscrew.

I have mentioned these species because they are some of our commonest wild flowers, so that during the summer and autumn we may, in almost any walk, observe for ourselves this innocent artillery. There are, however, many other more or less similar cases. Thus the squirting cucumber (*Momordica elaterium*), a common plant in the south of Europe, and one grown in some places for medicinal purposes, effects the same object by a totally different mechanism. The

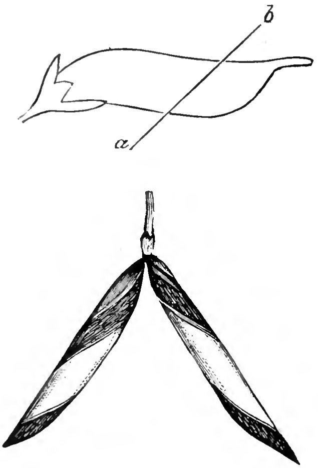


Fig. 9.—Vicia sepium. The line *a b* shows the direction of the woody fibres.

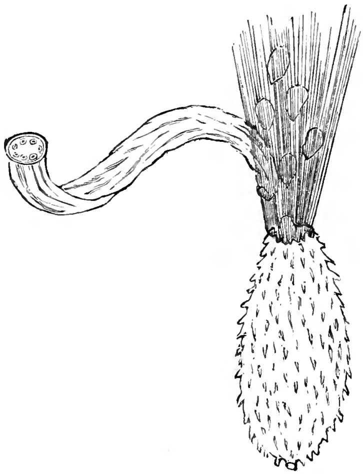


Fig. 10.—The Squirting Cucumber (*Momordica elaterium*.)

fruit is a small cucumber (Fig. 10), and when ripe it becomes so gorged with fluid that it is in a state of great tension. In this condition a very slight touch is sufficient to detach it from the stalk, when the pressure of the walls ejects the contents, throwing the seed some distance. In this case, of course, the contents are ejected at the end by which the cucumber is attached to the stalk. If any one touches one of these ripe fruits, they are often thrown with such force as to strike him in the face. In this the action is said to be due to endosmosis.

In *Cyclanthera*, a plant allied to the cucumber, the fruit is unsymmetrical, one side being round and hairy, the other nearly flat and smooth. The true apex of the fruit, which bears the remains of the flower, is also somewhat eccentric, and, when the seeds are ripe, if it is touched even lightly, the fruit explodes and the seeds are thrown to some distance. The mechanism by which this is effected has been described by Hildebrand. The interior of the fruit is occupied by loose cellular structure. The central column, or placenta, to which the seeds are attached, lies loosely in this tissue. Through the solution of its earlier attachments, when the fruit is ripe, the column adheres only at the apical end, under the withered remains of the flower, and at the swollen side. When the fruit bursts, the placenta unrolls, and

thus hurls the seeds to some distance, being even itself sometimes also torn away from its attachment.

Other cases of projected seeds are afforded by *Hura*, one of the *Euphorbiæ*, *Collomia*, *Oxalis*, some species allied to *Acanthus*, and by *Arceuthobium*, a plant allied to the mistletoe, and parasitic on junipers, which ejects its seeds to a distance of several feet, throwing them thus from one tree to another.

Even those species which do not eject their seeds often have them so placed with reference to the capsule that they only leave it if swung or jerked by a high wind. In the case of trees, even seeds with no special adaptation for dispersion must in this manner be often carried to no little distance; and to a certain, though less extent, this must hold good even with herbaceous plants. It throws light on the (at first sight) curious fact that in so many plants with small, heavy seeds, the capsules open not at the bottom, as one might perhaps have been disposed to expect, but at the top. A good illustration is afforded by the well-known case of the common poppy (Fig. 11), in which the upper part of the capsule presents a series of little doors (Fig. 11, *a*), through which, when the plant is swung by the wind, the seeds come out one by one. The little doors are protected from rain by overhanging eaves, and are even said to shut of themselves in wet weather. The genus *Campanula* is also interesting from this point of view, because some species have the capsules pendent, some upright, and those which are upright open at the top, while those which are pendent do so at the base.

FIG. 11.—SEED-HEAD OF POPPY (*Papaver.*)

In other cases the dispersion is mainly the work of the seed itself. In some of the lower plants, as, for instance, in many sea-weeds, and in some allied fresh-water plants, such as *Vaucheria*, the spores * are covered by vibratile cilia, and actually swim about in the water, like infusoria, till they have found a suitable spot on which to grow. Nay, so much do the spores of some sea-weeds resemble animals, that they are provided with a red "eye-spot" as it has been called, which, at any rate, seems so far to deserve the name that it appears to be sensitive to light. This mode of progression is, however, only suitable to water-plants. One group of small, low-organized plants (*Marchantia*) develop among the spores a number of cells with spirally thickened walls, which, by their contractility, are supposed to disseminate the spores. In the common horse-tails (*Equisetum*), again, the spores are provided with curious filaments, terminating in expansions, and known

* I need hardly observe that, botanically, these are not true seeds, but rather motile buds.

as "elaters." They move with great vigor, and probably serve the same purpose.

In much more numerous cases, seeds are carried by the wind. For this, of course, it is desirable that they should be light. Sometimes this object is attained by the character of the tissues themselves, sometimes by the presence of empty spaces. Thus, in *Valerianella auricula*, the fruit contains three cells, each of which would naturally be expected to contain a seed. One seed only, however, is developed, but, as may be seen from the figure given in Mr. Bentham's excellent "Handbook of the British Flora," the two cells which contain no seed actually become larger than the one which alone might, at first sight, appear to be normally developed. We may be sure from this that they must be of some use, and, from their lightness, they probably enable the wind to carry the seed to a greater distance than would otherwise be the case.

In other instances the plants themselves, or parts of them, are rolled along the ground by the wind. An example of this is afforded, for instance, by a kind of grass (*Spinifex squarrosus*), in which the mass of inflorescence, forming a large round head, is thus driven for miles over the dry sands of Australia until it comes to a damp place, when it expands and soon strikes root.

So, again, the *Anastatica hierochuntica*, or "rose of Jericho," a small annual with rounded pods, which frequents sandy places in Egypt, Syria, and Arabia, when dry, curls itself up into a ball or round cushion, and is thus driven about by the wind until it finds a damp place, when it uncurls, the pods open, and sow the seeds.

These cases, however, in which the seeds are rolled by the wind along the ground are comparatively rare. There are many more in which seeds are wafted through the air. If you examine the fruit of a sycamore you will find that it is provided with a wing-like expansion, in consequence of which, if there is any wind when it falls, it is, though rather heavy, blown to some distance from the parent tree. Several cases are shown in Fig. 12; for instance, the maple, *a*, sycamore, *b*, hornbeam, *d*, elm, *e*, birch, *f*, pine, *g*, fir, *h*, and ash, *i*, while in the lime, *c*, the whole bunch of fruits drops together, and the "bract," as it is called, or leaf of the flower-stalk, serves the same purpose.

In a great many other plants the same result is obtained by flattened and expanded edges. A beautiful example is afforded by the genus *Thysanocarpus*, a North American crucifer; *Th. laciniatus* has a distinctly winged pod; in *T. curvipes* the wings are considerably larger; lastly, in *T. elegans* and *T. radians* the pods are still further developed in the same direction, *T. radians* having the wing very broad, while in *T. elegans* it has become thinner and thinner in places, until at length it shows a series of perforations. Among our common wild plants we find winged fruits in the dock (*Rumex*) and in the common parsnip (*Pastinaca*). But though in these cases the object to be obtained—namely, the dispersion of the seed—is effected in a

similar manner, there are differences which might not at first be suspected. Thus in some cases, as, for instance, the pine, it is the seed itself which is winged; in *Thlaspi arvense* it is the pod; in *Entada*, a leguminous plant, the pod breaks up into segments, each of which is

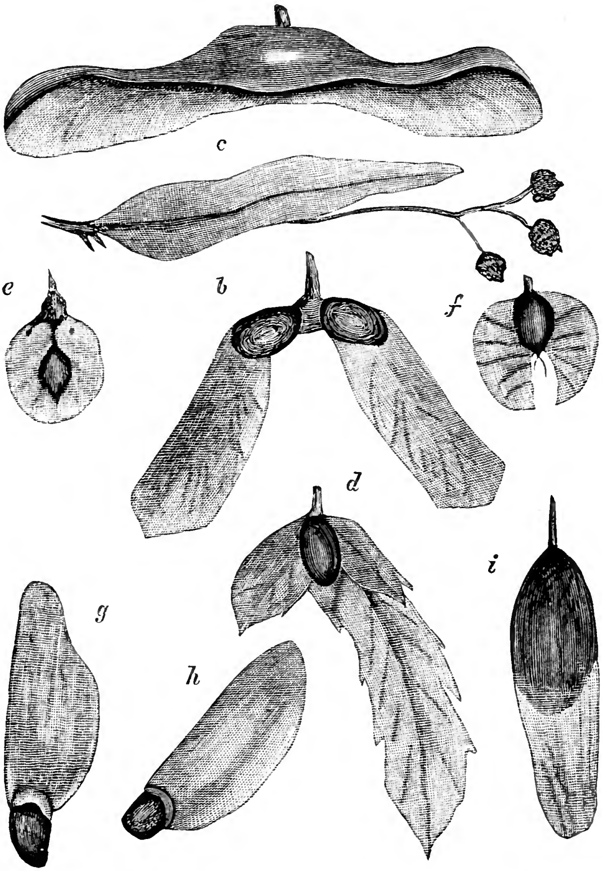


FIG. 12.—*a*, maple; *b*, sycamore; *c*, lime; *d*, hornbeam; *e*, elm; *f*, birch; *g*, pine; *h*, fir; *i*, ash.

winged; in *Nissolia* the extremity of the pod is expanded into a flattened wing; lastly, in the lime, as already mentioned, the fruits drop off in a bunch, and the leaf at the base of the common flower-stalk, or "bract," as it is called, forms the wing.

In *Gouania retinaria* of Rodriguez the same object is effected in another manner; the cellular tissue of the fruit crumbles and breaks away, leaving only the vascular tissue, which thus forms a net inclosing the seed.

Another mode, which is frequently adopted, is the development of long hairs. Sometimes, as in Clematis, Anemone, Dryas, these hairs take the form of a long, feathery awn. In others the hairs form a tuft

or crown, which botanists term a pappus. Of this the dandelion and John Go-to-bed-at-noon, so called from its habit of shutting its flowers about mid-day, are well-known examples. Tufts of hairs, which are themselves sometimes feathered, are developed in a great many Composites, though some, as, for instance, the daisy and lapsana, are without them: in some very interesting species, of which the common *Thrincia hirta* of our lawns and meadows is one, there are two kinds of fruits, as shown in Fig. 13, *b*, one with a pappus and one without. The former are adapted to seek "fresh woods and pastures new," while the latter stay and perpetuate the race at home.

A more or less similar pappus is found among various English plants—in the Epilobium (Fig. 13, *a*), Thrincia (Fig. 13, *b*), Tamarix

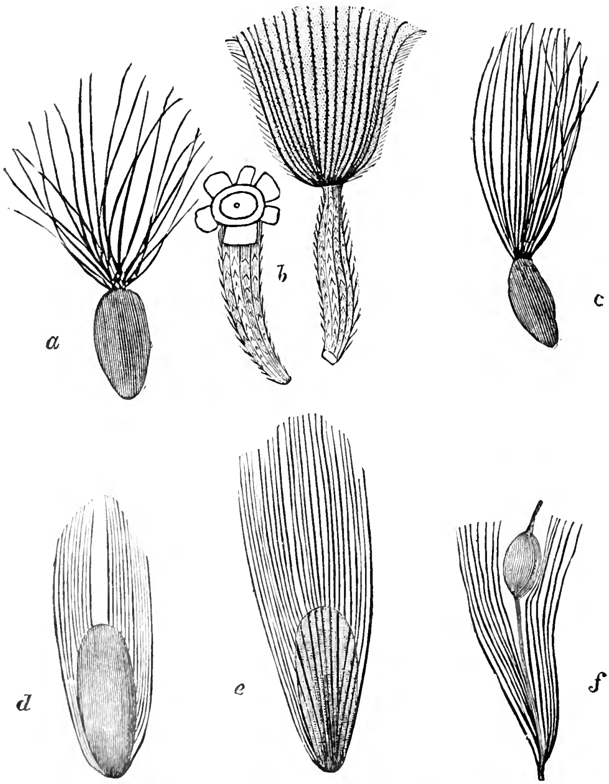


Fig. 13.—*a*, willow herb (*Epilobium*); *b*, two forms of seed of *Thrincia hirta*; *c*, Tamarix; *d*, willow (*Salix*); *e*, cotton grass (*Eriophorum*); *f*, bulrush (*Typha*).

(Fig. 13, *c*), willow (Fig. 13, *d*), cotton-grass (Fig. 13, *e*), and bulrush (Fig. 13, *f*); while in exotic species there are many other cases—as, for instance, the beautiful oleander. As in the wings, so also in that of the pappus, it is by no means always the same part of the plant which develops into the crown of hairs. Thus in the Valerians and Com-

posites it is the calyx; in the bulrush the perianth; in Epilobium the crown of the seed; in the cotton-grass it is supposed to represent the perianth; while in some, as, for instance, in the cotton-plant, the whole outer surface of the seed is clothed with long hairs. Sometimes, on the contrary, the hairs are very much reduced in number, as, for instance, in some species of *Æschynanthus*, where there are only three, one on one side and two on the other. In this case, moreover, the hairs are very flexible, and wrap round the wool of any animal with which they may come in contact, so that they form a double means of dispersion.

In other cases seeds are wafted by water. Of this the cocoanut is one of the most striking examples. The seeds retain their vitality for a considerable time, and the loose texture of the husk protects them and makes them float. Every one knows that the cocoanut is one of the first plants to make its appearance on coral islands, and it is, I believe, the only palm which is common to both hemispheres.

The seeds of the common duckweeds (*Lemna*) sink to the bottom of the water in autumn, and remain there throughout the winter; but in the spring they rise up to the surface again, and begin to grow.—*Fortnightly Review.*

[*To be continued.*]

SUNSTROKE AND SOME OF ITS SEQUELÆ.

By Sir JOSEPH FAYRER, M. D., F. R. S.

UNDER the designations of sunstroke, *coup-de-soleil*, heat-apoplexy, heat-asphyxia, thermic fever, ardent fever, insolation, and others, are included certain pathological states which, though differing from each other materially, are not unfrequently confounded.

1. There is simple syncope from exhaustion caused by heat.

2. A condition analogous to shock, due to the action of the direct rays of a powerful sun on the brain and cord; the nerve-centers, especially the respiratory, are affected; respiration and circulation rapidly fail, and death may result; recovery is frequent, though not always perfect.

3. Overheating of the whole body, blood, and nerve-centers, either from direct exposure to the sun's rays, or, more frequently, to a high temperature out of them; causing vaso-motor paralysis and intense pyrexia (fever); respiration and circulation fail, and asphyxia follows. Recovery frequently occurs, but is often incomplete, owing to structural changes in the centers, giving origin to a variety of symptoms indicative of lesions of a grave character.

The cases of simple exhaustion and syncope may occur during

great fatigue or over-exertion, or when there is depression of vital power from any cause during exposure to a high temperature. There is depression of nerve-force and of muscular power; the skin is pale, cold, and moist, the pulse feeble. Death may occur in this state from failure of the heart; but complete recovery more frequently occurs. Asphyxia and apnœa (stoppage of the breath) may come on after premonitory symptoms of depression and weakness, during exposure of the head and spine to the direct rays of a powerful sun, when the atmosphere is much heated, and the nervous energy is depressed by over-fatigue, illness, or dissipation. The brain and respiratory nerve-centers are overwhelmed by the sudden rise of their temperature, and respiration and circulation fail.

Recovery, though frequently complete, is sometimes tedious and occasionally imperfect, ending in serious impairment of health or intellect.

The symptoms of this form of sunstroke are those of sudden and violent derangement of the nerve-centers, unconsciousness, cold shivers, feeble pulse; all the signs of depression, terminating in death by shock; or fatal reaction may result with a variety of conditions pointing to injury to the cerebro-spinal system. In another class of cases there is ardent fever, the body generally, including the nerve-centers, is heated intensely; this may occur quite independently of the direct action of the sun's rays. It comes on frequently at night, or in the shade, in a building or tent, especially in persons who are depressed by fatigue, bad air, overfeeding, alcoholic stimulants and the consequent depression, want of rest, illness, and notably when the air is impure from overcrowding, or from insufficiency of cubic space.

The temperature of the body may rise to 108°–110°; respiration and circulation fail; there are hurried, gasping respiration, great restlessness; pungently hot skin, sometimes dry, occasionally moist. The pulse varies; in some it is full and laboring, in others quick and jerking; the head, face, and neck are livid and congested; the carotid pulsation is very perceptible; the pupils, at first contracted, dilate widely before death. Coma, stertor, delirium, convulsions frequently epileptiform in character, with relaxation of sphincter, and suppression of urine—these are the precursors of death by asphyxia, and it may be that there is cerebral hæmorrhage.

Such are the cases to which the term heat-apoplexy is given; and a large proportion of the fatal attacks among Europeans in India are so caused. Recovery may partially occur, to be followed by relapse and death, or secondary consequences, the result of tissue-change, may destroy life or impair health and intellect at a later period. The premonitory symptoms of this form of the disease may appear some hours or even days before the dangerous condition just described supervenes. There may be general *malaise*, disordered secretions, profuse and frequent micturition, restlessness, insomnia (sleeplessness), apprehension

of impending evil, hurried and shallow breathing, disturbance about the heart, gasping, giddiness, headache, occasionally nausea or vomiting, thirst, anorexia (want of appetite), feverishness, which soon amounts to fervent heat of skin ; the surface may be dry or moist, the pulse varies ; and these conditions gradually become aggravated and frequently are worse at night, when the patient passes into a state of unconsciousness and dies.

The symptoms point to a profoundly disturbed state of the cerebro-spinal nerve-centers, and to pathological changes in the organs whose functions have been so greatly disturbed.

Death is caused by asphyxia and apnœa, and in some cases probably by cerebral hæmorrhage. Recovery is often incomplete, resulting in permanent impairment of health, and generally in intolerance of heat and of exposure to the sun. These morbid conditions being due to heat alone, are liable to occur whenever there is exposure to a high temperature, whether solar or artificial. Soldiers marching or fighting, when oppressed by weight of clothing or accoutrements, are apt to suffer either from simple heat-exhaustion or from that form of insolation which results from direct action of a powerful sun on the head and spine. Soldiers, laborers, artificers, and people in factories, heated rooms, hospitals, barracks, tents, and even ships, may suffer from heat-exhaustion, which may pass into the same dangerous condition of heat-asphyxia. People in the hay-field, or otherwise exposed to great heat, especially if they have indulged in excess of alcoholic stimulants and food, may suffer. Weak persons with defective hearts may die in this state of syncope. Soldiers or others, when exposed to great heat, may drop out of the ranks, fall in a state of syncope and die on the spot, or pass into a state of coma and die later ; or they may recover, after being in great danger, with damaged nerve-centers, and are rendered quite unfit for further service, or even residence in a hot climate. These cases occur on exposure to the direct action of the sun's rays when the atmospheric temperature is also high, and especially when unusual exertion is made, or when the individual is depressed by previous illness or the exhaustion due to dissipation, intemperance, or even undue indulgence in stimulants.

But the most serious cases are those that come on under cover by night as well as by day, and apart from the direct solar rays. Heat alone, especially when the atmosphere is loaded with moisture so as to prevent evaporation from the person, is the real cause of the disease.

Vigorous, healthy persons of moderately spare frame, with sound viscera, and who are of temperate habits, if the atmosphere be pure and moderately dry, can sustain a great amount of heat. Acclimatization has also some influence in conferring toleration. Fresh arrivals in the tropics are more prone to suffer than those who have become accustomed to the climate, and have learned how to protect themselves. It is well known that a native can bear an amount of sun on

his bare head and naked body with indifference, almost pleasure, that would rapidly prostrate a European. But when the temperature rises above a certain standard all succumb, and natives of India suffer and die like others in numbers every year from *loo marna* (hot-wind stroke).

The extent and duration of the toleration of heat depend much on the vigor of constitution and actual state of health. The refrigerating powers of the body, when in health, enable it to support a very high temperature, considerably above that of the blood. Thus, in the hot winds little inconvenience is felt so long as perspiration is free, but, when that fails, suffering soon ensues, and the danger is great.

In the fourteenth annual report of the Sanitary Commissioner with the Government of India, 1877, it is stated that two hundred and thirty-five cases of heat-apoplexy and sunstroke occurred in the army in India, of which seventy were fatal. Of those who recover, or rather do not die, many are permanently injured, and remain invalids for the rest of life, which is frequently shortened by the changes induced.

No remarkable morbid change is observed in cases where death has occurred suddenly. The heart may be firmly contracted, and the lungs and brain and its membranes congested, but not invariably, for sometimes the reverse conditions exist; and the blood is dark and clotted, its coagulability is impaired, and it is deficient in oxygen. In death from ordinary cases of thermic fever or insolation, the pulmonary system is often deeply congested; the heart is firmly contracted with coagulation of myosin; the venous system is engorged; the body may be marked with livid patches; the blood shows a tendency to a separation of its fluid and solid constituents, and may be acid in reaction; and the body retains a high temperature for some time after death. The brain and membranes may be congested, but the disease is essentially asphyxia, not apoplexy.

In cases of simple exhaustion, remove the person to a cooler place, if possible. Give a douche, but not too prolonged, or it may over-depress. A stimulant may be useful; rouse, and gently stimulate; remove tight and oppressive clothing. Treat as in ordinary fainting—apply ammonia to nostrils, etc. Let the patient rest, and avoid exposure to over-fatigue or to great heat. In the form of sunstroke where the person is struck down suddenly by a hot sun, remove him into the shade, and allow a douche of cold water to fall from a height on his head and body. This should be freely resorted to, the object being twofold—to reduce the temperature of the over-heated centers, and to rouse by reflex action. During the assault on the "White-House picket," at the capture of Rangoon in 1853, numbers of men were struck down by the fierce April sun. They were brought to me, and laid out in rows, perfectly unconscious, *in their red coats and black leather stocks*. They nearly all recovered—for the time, at all events—under the influence of the douche, freely applied over the head and

body. In some cases rousing by flagellation with the sweeper's broom was added with great effect, especially in the case of Brigadier-General W——, who I thought must have died. All, or nearly all, recovered, except two, both of whom had been bled on the spot before I saw them.

In addition to the douche, stimulants, such as mustard-plasters, to various parts of the body, legs, abdomen, etc., and stimulating injections, which relieve the loaded bowels and at the same time rouse, may be useful.

When I say such cases recovered, I refer to the reaction at the time. In some there were consecutive symptoms of fever, headache, etc.; and, were we able to trace their subsequent history, we should probably find that complete recovery never occurred. If recovery is incomplete, and followed by indications of disordered nerve-centers or of meningitis, other treatment of a more active character will be needed, according to the conditions.

Future exposure to the sun should be carefully guarded against, and, unless recovery has been rapid and complete, the sufferer, if in India or the tropics, should be removed to a cooler climate, where he should be protected from all excitement of mind or body, and the greatest care be taken not only to avoid all errors or excesses of diet, but also of stimulants.

In the graver cases of thermic fever, or heat-asphyxia, heat being the primary cause of the disease, the object is to reduce temperature as speedily as possible and before tissue-changes have been caused. Remedies adapted to fevers may be used sometimes with advantage. Bleeding has now happily been abandoned except in rare and peculiar cases. The treatment, generally, consists in the judicious application of cold by affusion, or by ice, taking care not to reduce temperature too low. Great care should be taken not to prolong the cold application too far, as danger would attend continued depression of the temperature below the normal standard of blood-heat. The bowels should be relieved, and blisters may be applied to the scalp and neck, though I can not but say I have not much faith in their efficacy. In the epileptiform convulsions that so frequently occur, the inhalation of chloroform may be useful, but its administration must be carefully watched. The earliest and most severe symptoms having subsided, the febrile condition that follows is to be treated on ordinary principles; the diet must be carefully regulated. As improvement progresses, symptoms of intra-cranial mischief may begin to supervene; where the indications are of meningitis, iodide of potash and counter-irritation may be of service; removal to a cooler climate is essential.

The sequelæ of sunstroke are often very distressing, and render the patient a source of anxiety and suffering to himself and to his friends.

Among them are, in various degrees of intensity, irritability, im-

paired memory, epilepsy or epileptiform attacks, headache, mania, partial or complete paraplegia (paralysis of the lower half of the body), partial or complete blindness, extreme intolerance of heat, especially of the sun's rays, rendering a person otherwise fairly healthy quite incapable of living in hot climates or of enduring any exposure to the sun; or, the attack may gradually end in complete fatuity, dementia, or epilepsy, perchance both; chronic meningitis, with thickening of the calvarium, accounting for the intense pains in the head; or, in a lesser degree, in disordered nervous condition and general functional derangement.

The less severe symptoms—those probably of the slighter forms of meningitis, or of cerebral change—occasionally pass away after protracted residence in a cold climate; they are, however, not unfrequently the cause of suffering, and of danger to and shortening of life, pointing to permanently disturbed if not structurally altered cerebro-spinal centers.—*Abridged from Brain.*

THE VALUE OF OUR FORESTS.

By N. H. EGLESTON.

IT may be considered as now established, by the most careful and intelligent investigation of the subject, that the highest welfare of almost any country demands that from one fifth to one fourth of its surface shall be covered with trees, and that these shall be, to a good degree, in masses. England will at once be adduced, perhaps, as a country not well wooded, and yet one which compares favorably with others in regard to the conditions of living and her competency to secure the welfare of all classes of her people. But England is specially favored in other respects. She has a moist and equable climate secured to her by her surrounding seas and high latitude, while the general shape of her surface and her geological constitution exempt her from the alternations of flood and drought which in so many other countries result from the absence of forests.

Whether the forests insure a greater rainfall in their vicinity than is received upon an equal area of open land has been disputed among scientific men, though the preponderance of opinion now seems to favor the conclusion that the rainfall is most abundant in wooded regions. This corresponds also with the prevalent belief of the common people, the unscientific but practical observers.

A special committee of the Royal Academy of Vienna, reporting in 1874 upon a "Memoir of Mr. Hofrath Wex upon the Diminution of the Water of Rivers and Streams," used the following language upon this particular point: "The question of the influence of forests upon

the amount of precipitation has for some time engaged the attention of naturalists. Such an influence has been asserted, partly from theoretic considerations and partly on account of the entire change presented by the climatic relations of the countries in which the forests have disappeared. . . . It is probable that such influence exists; but while on the one hand its consequences may be over-estimated, on the other hand there is want of direct proof, inasmuch as the rain measurements have been continued for too short a time, both at stations situated within the woods and outside of them in the open fields. . . .

"The commission consequently concluded that an influence of the woods upon the amount of rain deposited, and especially upon the yearly contribution, is probable, although direct observation does not give sufficient evidence to determine its extent, or positively its existence."

Dr. Rogers, of Mauritius, gives this testimony: "So late as 1864 the island was resorted to by invalids from India, as the 'pearl' of the Indian Ocean—it being then one mass of verdure. But, when the forests were cleared to gain space for sugar-cultivation, the rainfall diminished, the rivers dwindled down to muddy streams, the water became stagnant in cracks, crevices, and natural hollows, while the equable temperature of the island entirely changed, drought was experienced in the midst of the ocean, and thunder-showers were rarely any longer witnessed. . . . The hills were subsequently planted with trees, and the rivers and streams resumed their former dimensions."

The Island of Ascension was formerly almost a barren rock. The supply of water was very scanty, derived solely from a few springs, and water was often brought from the Cape of Good Hope, and even from England, for the needs of the garrison. About twenty-five years ago the planting of trees and shrubs and the cultivation of the soil were undertaken vigorously. The water-supply has increased with the progress of this work, until now it is excellent, and the garrison and ships visiting the island are supplied with abundance of water and vegetables of various kinds.

Observations in France by M. Fautrat, reported to the Academy of Sciences, showed that, in a dense wood of five hundred hectares, a rain-gauge fixed on a tall poplar received much more water than one of similar height three hundred metres beyond the borders of the woods. Experiments continued during two years confirmed the first results, and an instrument placed over a forest of *Pinus sylvestris*, at twelve metres' elevation, received ten per cent. more water than one at the same height in the open fields.

But, however the case may be as to the effect of forests upon the amount of rainfall, there can be no doubt that they secure a more equable distribution of the rains than is usual in the open country. They are also great storehouses of moisture. By their myriad leaves they intercept the moisture of the passing clouds or the damp winds, and convey it to the ground, or hold it within their embrace ready to

be given out again to a drier atmosphere and to surrounding objects. It is well known, also, that the leaves of the trees, as they fall from year to year and decay, form a spongy soil, which absorbs the rains that fall upon it, and retains them, when otherwise, where there is any declivity, the water would run off almost immediately. The roots of the trees, likewise, penetrating deeply into the ground, conduct a considerable portion of the moisture falling from the clouds far below the spongy surface-soil.* Shaded by the leaves and branches of the trees, the moisture thus stored up is not soon evaporated, as it would be from the open ground, but passes off slowly into the surrounding air, and imparts its benefits in the largest measure to the adjacent lands.

While thus sending out their moisture upon the cultivated fields around them, and thereby favoring the growing crops, the forests aid the work of husbandry in another way. By their very mass they serve as a mechanical barrier against the winds, which are often so injurious to crops. Every one who has visited the forest with any frequency knows that he is obliged to go but a short distance within its borders to escape the influence of even a violent wind. So it is also well known that the woodmen engaged in felling trees in the forest, which they usually do in the winter, find no inconvenience from cold winds, as these penetrate the wood but a short distance, even when the trees are stripped of their leaves. And as the woods shelter those within them from the winds, so do they protect the adjacent fields from the blasts which would otherwise sweep over them, and, by their cold, their mechanical force, and their desiccating influence, prove very injurious to crops. The presence of a forest is often, on this account, in its effect upon adjacent lands, equivalent to a change of latitude of several degrees. This is sufficient to make the cultivation of certain crops successful which otherwise could not be undertaken. There are districts of France and Italy where the olive and the orange once flourished, but where now, on account of the change of climate resulting from the extensive removal of the forests which formerly abounded, they can no longer be grown with success. It is not going too far to say that, if one fourth of the land now under cultivation were converted into forests and groves so disposed as to form barriers against the coldest and strongest or most prevalent winds, the remaining three fourths would have more value for agricultural purposes than the whole has at present. This would result from the greater variety of crops which could be raised, their earlier maturity, the greater certainty of growth, and the larger aggregate yield, while there would be, in addition, the large product of the forest itself, to be used, as occasion might demand, for fuel and lumber.

The effect of trees in preventing or diminishing the evaporation from the ground caused by the passage of drying winds is far from being properly appreciated. We often speak of the effect of wind in

drying muddy roads as being greater than that of sunshine, while we fail to recognize the fact that the desiccating effect is the same upon the fields as upon the roads.

Forests have a very obvious influence also in preventing the occurrence of floods and droughts. When the rains fall upon the open, unwooded country, unless it is of a quite level character, they flow off at once into the beds of the neighboring streams, and pour their united flood into the larger rivers, swelling their volume rapidly to such an extent that their waters can not be confined within their banks, but break out and overspread the adjacent lands, carrying destruction oftentimes to the growing crops, covering fertile fields with masses of gravel and rubbish of various sorts, interfering with manufacturing interests, and often destroying life itself. These floods are succeeded by periods of drought. The flow of water in the streams shrinks away, often leaving their beds almost dry. As a consequence, crops and herds suffer, the mill-wheels are stopped or turn but slowly and feebly, the transportation of merchandise is impeded, and the various industries of life suffer. The forests prevent such a deplorable condition of things. The spongy soil formed by their fallen leaves, accumulated for years, retains the rain which falls upon it as in a great reservoir, and obliges it to flow off gradually instead of with a sudden flood. The difference in the operation in the two cases may be likened to that between the flow of the rain from a smoothly shingled house-roof and from one covered with thatch. In the one case the water runs at once to the ground without any impediment. In the other it sinks into the straw to a considerable depth and trickles thence for days perhaps after the rain has ceased to fall. So, our hillsides and mountain-slopes, where the forests are most usually found, are the world's great roofs or water-sheds, from which, if they are thatched with trees, the water flows off slowly and in the most desirable manner into the streams and upon the lands of the regions below, but, if stripped of this protecting covering, then with sudden and disastrous flood which no art of man can withstand.

This is well illustrated by the report of the effect of a storm in two neighboring ravines in the valley of the Durance in southeastern France, the Ravine de St. Phalez and the Ravine de la Combe d'Yeuse. St. Phalez runs north and south, has a basin of reception fifty hectares (one hundred and twenty-five acres) in extent, is well cultivated and has an argillaceous soil. Combe d'Yeuse is much more steep, has a basin of reception of two hundred and fifty hectares (seven hundred and twenty-five acres), and is covered with pines and oaks. In other respects the two ravines are alike.

In September, 1864, an abundant rainfall took place. On the morning after the rain the ravine of St. Phalez was flowing with a small stream. The Combe d'Yeuse was dry. During the day a water-spout struck the mountain and prevailed for not more than forty min-

utes; hardly had it begun when the torrent of St. Phalez became awful; it filled the ravine from bank to bank, seizing and carrying off rocks which had been used to form a road, which was considered safe against all contingencies. At the same time, that of Combe d'Yeuse and all those traversing wooded lands remained dry or carried a comparatively insignificant quantity of water.

The forest conservator describes a second scene on the same spot in the following October. In a few minutes after the rain began, the torrent of St. Phalez gushed forth with the same destructive effect as before. But after an entire day of rain a small stream appeared coming down the Ravine d'Yeuse, which increased for three days and then for two declined. The only damage done was to a little footpath. "Thus we have," says the reporter, "two torrents very near to each other, and exposed to the same conditions, except that the basin drained by the one comprises fifty hectares of cultivated lands, that of the other two hundred and fifty hectares of woodlands. The first receives and allows to flow away the waters of the greater part of a storm in a few hours at most, causing thereby considerable damage; the second, which has received a greater quantity of rain, stores it—keeps it for two days—evidently retaining a portion of it, and takes three or four days to yield up the surplus, which it does in the form of a limpid and inoffensive stream."

So also in the colder latitudes, where during the wintry months the moisture of the atmosphere is precipitated in the form of snow and accumulates often to a great depth, the conservative influence of the forest is very obvious. The temperature of the woods is warmer in winter, as it is cooler in summer, than that of the open ground. Sheltered from the winds and, to a considerable degree, from the cold, the snows themselves forming a protecting covering, the earth seldom freezes in the forest, and the warmth from the ground below gradually melts the snow and so feeds the springs and streams as to maintain in them an equable flow. As the warmer sun and wind of advancing spring-time begin to heat the surface of the ground, the screen of the trees prevents their influence from being so sensibly felt in the woods as in the open fields. The result is, that the snows dissolve gradually, and the resultant water, sinking in the first place and for the most part into the spongy, leafy soil, flows away gently, as do the rains of summer-time, into the valleys and fields below. But, when the forests have been removed, the case is very different. The snows, no longer screened from the sun's rays and the warm winds by the interposed foliage or even the naked trunks of the trees, are rapidly dissolved, often before the earth beneath or the ground over which the waters must flow has been unlocked from the wintry frosts. As a necessary result, thousands of rivulets are formed almost at once, which are precipitated into the adjacent streams, whose rapidly increased volumes are hurried to the larger streams below, and thus we

have our spring floods, often so destructive to property as well as life.

There is another aspect in which the forests are to be regarded, but in which we have hardly begun to consider them properly, and that is the economical one, as the continuous producers of fuel, and of lumber for use in the mechanic arts. With our boundless area of cheap lands, covered originally with forests to such an extent that the trees have been regarded as an obstruction to agriculture, and so to be swept away often by fire rather than to await the slower process of the axe, we have thought little of the forest as anything of permanent value. Added to this the practically unlimited area of our coal-fields has served to prevent any apprehension of loss from the destruction of the forests. That there is ever to come a time when we may suffer from a scarcity of wood for fuel or for the arts, hardly seems to have entered many minds.

Very different is the settled feeling in other countries in respect to the value of the forests. When in some portions of Europe the peasant has to travel miles on foot to bring home, as the result of a whole day's labor, an armful of wood to burn, and can afford to bake bread but once in six months because fuel is so scarce and dear ; and when England, with only four or five per cent. of woodland, is gravely and anxiously figuring out the time when her coal-fields will be exhausted, and her vast manufacturing interest will be at the expense of purchasing its fuel from other countries or suffer inevitable decline or extinction—the importance of the forest, in an economical as well as in a political point of view, becomes at once apparent. The coal-fields are not growing, and never can be made to grow again. They were deposited ages since, once for all, and, so far as we can see, are to have no successors or substitutes but the living trees, following each other from generation to generation.

It is not to be wondered at, therefore, that the European nations, having learned its value by its loss in greater or less measure, see the forest to be an important factor in all that constitutes national life and comfort, and have given it a place in their thoughts and in their practical arrangements which we have not in ours. It is not surprising that they should establish schools for the special purpose of teaching all that relates to the growth and preservation of the forest, that they should make it a matter of national and political concern, and that the literature of the subject should be so extensive that it is estimated that from the German press alone as many as a hundred volumes and pamphlets on forestry, in some of its aspects, are issued annually.

Germany has given much attention to her forests ever since the days of Charlemagne, who is said to have afforested the Ardennes and established the forest of Osnabrück. The sovereigns of Germany have treated the woodlands not merely as preserves for game and

places for royal enjoyment in its pursuit, but have encouraged their cultivation for the production of fuel and timber, as well as for their value in other respects. It will indicate the careful attention given to the forests in Germany, when we find it officially reported that the net returns of the forests are from two to twelve thalers per hectare (two and a half acres), and the value of the land together with its crop is estimated at fifty-two and a half thalers per hectare.

England, now having a smaller percentage of forest than any country of Europe, with the exception of Spain and Portugal, was well wooded at the remotest historical period; but as early as the thirteenth century, in the time of Henry III, she found it necessary to import pine-lumber, and apprehension began to be felt of the failure of the forests.

Hardly anything has been done in England compared with what has been done in Germany, France, and other Continental countries, to establish and protect the forests. Individuals have done something, as for instance the Duke of Athol, who, in the early part of the present century, planted several thousand acres of the barren hillsides of Scotland with the larch. His successors in the dukedom have followed his worthy example and extended the woodland area, and demonstrated that the work of forestry, rightly prosecuted, is pecuniarily profitable as well as desirable in other respects. It is only within the last few years that the English Government has shown any considerable interest in this subject. Some action has been taken for the purpose of protecting the forests in her colonies from destruction, and quite recently a few thousand acres in England itself have been planted with oaks for the purpose of meeting the future demands of the navy.

The subject of the preservation of the woods is one of the highest practical importance. Man has often acted very unwisely in the exercise of his lordship of the forest, and has suffered greatly, and continues to suffer, in consequence. Great districts once populous, and powerful as populous, have been almost converted into deserts, some of them quite into deserts, and their people diminished in numbers and in power, as the result of a wanton destruction of their forests. France and other European countries have been swept by disastrous floods, or rent by torrents rushing down their mountain-slopes, and carrying masses of rock and gravel into the valleys and plains below, because the forests which would have held the floods in check have been recklessly consumed; and now forest schools are established, and all the power and wealth of governments are put forth for the purpose of staying these evil effects, if possible, by replanting the mountain-sides with trees, and thus restoring the protection which Nature had originally provided. Climates have been changed for the worse, the agricultural productiveness of countries has been lessened, provinces have been depopulated, the health and happiness of nations have been diminished, by the destruction of the forests; and now sci-

ence and art and governmental authority are invoked to unite their powers for the purpose of remedying the evil results.

We are treading the same course that other nations have trod. Says Humboldt, "Men, in all climates, seem to bring upon future generations two calamities at once—a want of fuel and a scarcity of water." With our comparatively sparse population and our continental stretch of forest, it has hardly entered our minds that we could be improvident in the use of our woodlands. It has seemed to us that we had enough, and that for ever ; and so we have consumed the forests with a recklessness which has perhaps never been surpassed. We have even sacrificed them by carelessness, or in the wantonness of a temporary greed, utterly regardless of the future. Forests which have been the growth of centuries have been swept off in a day. The lumberman cuts the few noblest trees, or takes only the choicest portions of them for the purposes of the arts, and burns the rest to ashes, thereby precluding another growth upon the spot. The miner does the same, cutting off the already sparse forests, and taking no pains to replace them. And so it is happening that our forest area, particularly in the more recently settled portions of the country, is rapidly diminishing. The opening of the great agricultural regions of the Ohio and the Mississippi Valleys, with their superior attractiveness, has lessened the value of much of the Eastern lands for the purpose of tillage, and, in some portions of New England particularly, what were once corn-fields and pastures, have been abandoned by the cultivator and a growth of trees has come in. But as a whole our forest area has been diminishing for a long time, and never more rapidly than within the last decade. Serious evils have already come from this wasting of the woods, but they have been spread over so wide a stretch of territory that attention has not been called to them in a way to arouse general attention or lead to their remedy. Our streams have a diminished flow of water, while they are marked by alternations of floods and droughts, much greater than formerly prevailed. They are not navigable for so long distances, nor for so large a class of boats, as they once were, nor do they furnish so large or so uniform a supply for the mill-wheels as they did in earlier times. Changes of climate have also resulted, affecting the health of the people and the productiveness of the fields. These effects have been noticed in a multitude of cases. But, in most instances, they have been regarded as isolated and local occurrences, and have not been attributed to their true cause.

In some of our Western States which are almost treeless, the beneficial influence of forests has been forced upon the attention of the people. It has been found that life may not be worth living, though on the richest soil, if that be all. A writer of acknowledged authority, in a lecture before the Illinois Industrial University, speaking of the importance of trees as a shelter of crops from injurious winds, says, "I think it may be safely estimated that an average of one twelfth part of

all our crops of grain and large fruits is destroyed by violent winds, which such a system of protection, or its equivalent in groves, would so far check as to prevent the destruction." Another, whose words are quoted in the "Iowa Horticultural Report" for 1875, speaking of the wintry storms of the Northwest, sometimes known as "blizzards," says, "More people have been frozen within the last year in northwest Iowa and west Minnesota than were ever murdered by the Indians in those counties since their settlement." And he says, in regard to a remedy: "I see none that would do but timber-planting. It alone would stop these terrible winds, modify the climate, and furnish landmarks for the traveler." So Professor Lacy, of the State University, in an address to the Minnesota State Forestry Association, says: "The Minnesota State Forestry Association was organized to meet and deal with the stern realities of facts. It was organized to meet the fact that over more than one third of the great State of Minnesota the winds rush with a howling fury and with a bitter cold that neither beast nor fruit-tree can resist or withstand, and for miles not a single forest-tree rears its head in protest. It was organized to meet the fact that, in a climate which affords six months of winter, much of it fearfully severe, there are thousands of farms on which there does not grow one particle of fuel, and on which it can not be obtained without the expenditure of both money and labor by a people often destitute of means. It was organized to meet the fact that for miles and miles there is not a single landmark to guide the benumbed and benighted traveler. It was organized to meet the fact that to induce human beings to make their houses on such farms is downright inhumanity. . . . The force of the winds on our Western prairies can not be conceived of by you who have always lived within the area of forests. They are simply terrible to endure and appalling to contemplate. They carry death alike to the unprotected beast and the more tender forms of arboreal life."

It is not surprising that people living amid such exposures of life and property, and seeing so manifestly as they do that these are attributable to the absence of trees, should bestir themselves in seeking the appropriate remedy, that they should organize, as they have done, forestry associations, appoint arbor-days, and engage the aid of the State itself in offering bounties for tree-planting, and in exempting forest plantations for a time from taxation. The latter has been done in several of the Western States, and already the work of tree-planting has wrought a perceptible change on many a farm, as to appearance, comfort of living, and productiveness. But the work that is needed is a great one, a work not to be accomplished by planting in a few States or portions of States lines of quick-growing, soft-wooded trees, which may make tolerable wind-breaks in five or six years. This is hardly more than a makeshift at the best. The work is broader and more comprehensive than that, and one which for its due accomplishment needs an intelligent comprehension of the facts

involved in the case, and their far-reaching relations. It is a matter not of present or local exigency merely, but of general and abiding importance. The future of the whole country is involved in it.

Champollion is reported as saying in reference to the great desert of Northern Africa: "And so the astonishing truth dawns upon us that this desert may once have been a region of groves and fountains, and the abode of happy millions. Is there any crime against Nature which draws down a more terrible curse than that of stripping Mother Earth of her sylvan covering? The hand of man has produced this desert, and, I verily believe, every other desert upon the surface of this earth. Earth was Eden once, and our misery is the punishment of our sins against the world of plants. The burning sun of the desert is the angel with the flaming sword who stands between us and paradise."

An awakening of general interest on this subject is needed. To this end the most important step is to get before the people as widely as possible the facts showing the importance of the forests in their relations to climate, to water-supply, to floods and droughts, to commerce and manufactures, to agriculture and to health; the rapidity with which we are destroying our forests and bringing upon ourselves the natural and inevitable results of that course. The history of other nations, as related to their treatment of the forests, should be made widely known, and the danger that this land, or portions of it, by the reckless destruction of its forests, may be converted into a desert, as other lands have been. Thus may we hope to arouse a general interest in the trees, and a disposition to cherish them as our best friends. Meanwhile, let tree-planting be encouraged. Let it be shown, as it has been again and again, that much of our poor and what is commonly regarded as waste land can be made to yield a handsome profit by being devoted to the growth of trees; and that our rough hills and mountain-sides can thus be made of direct pecuniary value, while at the same time they are rendered objects of beauty and the means of protecting our springs, maintaining the flow of our streams, and promoting health and prosperity. With this awakened interest in the forests, sylviculture will come to be one of our arts. We want an intelligent and scientific observation of the facts in regard to trees as related to our various soils and situations. The adaptation of trees to one climate or another, their comparative value for one purpose or another, the obstacles to successful planting—these, and many other things, need to be known as they are not yet known. Some things we can learn from the experiments which have been made and the knowledge which has been gained in Europe. But so different are the trees there and here, and so different the conditions of soil and climate, that the problem set before us is virtually a new one, which must be worked out carefully and patiently on our own ground. The most important advance in this direction yet made here, so far as we know,

has been by the Bussey Institute, in connection with the Arnold Arboretum, at Brookline, Massachusetts. Under the able and judicious management of Professor Sargent, it has already fine plantations of forest-trees, has diffused much valuable information in regard to the growth and importance of trees, and has secured the planting of a large number in various parts of the country. On the foundation of such institutions will naturally be built up in due time schools of instruction in forestry like those of Europe, which will have a recognized and permanent place among us. The European schools of forestry will form the subject of another article.

PRODUCTION OF SOUND BY RADIANT ENERGY.*

By ALEXANDER GRAHAM BELL.

IN a paper read before the American Association for the Advancement of Science, last August, I described certain experiments made by Mr. Sumner Tainter and myself which had resulted in the construction of a "*Photophone*," or apparatus for the production of sound by light; † and it will be my object to-day to describe the progress we have made in the investigation of photophonic phenomena since the date of this communication.

In my Boston paper the discovery was announced that thin disks of very many different substances *emitted sounds* when exposed to the action of a rapidly-interrupted beam of sunlight. The great variety of material used in these experiments led me to believe that sonorousness under such circumstances would be found to be a general property of all matter.

At that time we had failed to obtain audible effects from masses of the various substances which became sonorous in the condition of thin diaphragms, but this failure was explained upon the supposition that the molecular disturbance produced by the light was chiefly a surface action, and that under the circumstances of the experiments the vibration had to be transmitted through the mass of the substance in order to affect the ear. It was therefore supposed that, if we could lead to the ear air that was directly in contact with the illuminated surface, louder sounds might be obtained, and solid masses be found to be as sonorous as thin diaphragms. The first experiments made to verify

* A paper read before the National Academy of Arts and Sciences, April 21, 1881. (From author's advance-sheets.)

† "Proceedings of American Association for the Advancement of Science," August 27, 1880; see, also, "American Journal of Science," vol. xx, p. 305; "Journal of the American Electrical Society," vol. iii, p. 3; "Journal of the Society of Telegraph Engineers and Electricians," vol. ix, p. 401; "Annales de Chimie et de Physique," vol. xxi.

this hypothesis pointed toward success. A beam of sunlight was focused into one end of an open tube, the ear being placed at the other end. Upon interrupting the beam, a clear, musical tone was heard, the pitch of which depended upon the frequency of the interruption of the light and the loudness upon the material composing the tube.

At this stage our experiments were interrupted, as circumstances called me to Europe.

While in Paris a new form of the experiment occurred to my mind, which would not only enable us to investigate the sounds produced by masses, but would also permit us to test the more general proposition that *sonorousness, under the influence of intermittent light, is a property common to all matter.*

The substance to be tested was to be placed in the interior of a transparent vessel, made of some material which (like glass) is transparent to light, but practically opaque to sound.

Under such circumstances the light could get in, but the sound produced by the vibration of the substance could not get out. The audible effects could be studied by placing the ear in communication with the interior of the vessel by means of a hearing-tube.

Some preliminary experiments were made in Paris to test this idea, and the results were so promising that they were communicated to the French Academy on October 11, 1880, in a note read for me by M. Antoine Breguet.* Shortly afterward I wrote to Mr. Tainter, suggesting that he should carry on the investigation in America, as circumstances prevented me from doing so myself in Europe. As these experiments seem to have formed the common starting-point for a series of independent researches of the most important character, carried on simultaneously, in America by Mr. Tainter, and in Europe by M. Mercadier,† Professor Tyndall,‡ W. E. Röntgen,# and W. H. Preece,‖ I may be permitted to quote from my letter to Mr. Tainter the passage describing the experiments referred to:

METROPOLITAN HOTEL, RUE CAMBON, PARIS, *November* 2, 1880.

DEAR MR. TAINTER: . . . I have devised a method of producing sounds by the action of an intermittent beam of light from substances that can not be obtained in the shape of thin diaphragms or in the tubular form; indeed, the method is specially adapted to testing the generality of the phenomenon we have discovered, as it can be adapted to solids, liquids, and gases.

Place the substance to be experimented with in a glass test-tube, connect a

* "Comptes Rendus," vol. cxl, p. 595.

† "Notes on Radiophony" ("Comptes Rendus," December 6 and 13, 1880; February 21 and 28, 1881). See, also, "Journal de Physique," vol. x, p. 53.

‡ "Action of an Intermittent Beam of Radiant Heat upon Gaseous Matter" ("Proceedings of the Royal Society," January 13, 1881, vol. xxxi, p. 307).

\# "On the Tones which arise from the Intermittent Illumination of a Gas." (See "Annalen der Physik und Chemie," January, 1881, No. 1, p. 155.)

‖ "On the Conversion of Radiant Energy into Sonorous Vibration" ("Proceedings of the Royal Society," March 10, 1881, vol. xxxi, p. 506).

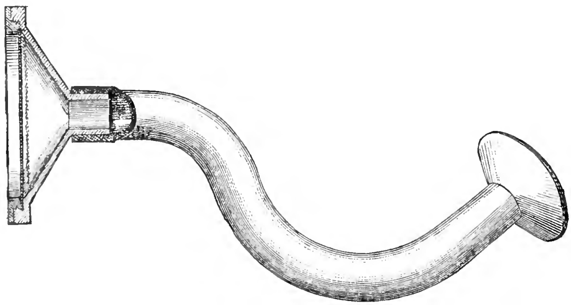
rubber tube with the mouth of the test-tube, placing the other end of the pipe to the ear. Then focus the intermittent beam upon the substance in the tube. I have tried a large number of substances in this way with great success, although it is extremely difficult to get a glimpse of the sun here, and when it does shine the intensity of the light is not to be compared with that to be obtained in Washington. I got splendid effects from crystals of bichromate of potash, crystals of sulphate of copper, and from tobacco-smoke. A whole cigar placed in the test-tube produced a very loud sound. I could not hear anything from plain water, but when the water was discolored with ink a feeble sound was heard. I would suggest that you might repeat these experiments and extend the results. . . .

Upon my return to Washington in the early part of January,* Mr. Tainter communicated to me the results of the experiments he had made in my laboratory during my absence in Europe.

He had commenced by examining the sonorous properties of a vast number of substances inclosed in test-tubes in a simple empirical search for loud effects. He was thus led gradually to the discovery that cotton-wool, worsted, silk, and fibrous materials generally, produced much louder sounds than hard, rigid bodies like crystals, or diaphragms such as we had hitherto used.

In order to study the effects under better circumstances, he inclosed his materials in a conical cavity in a piece of brass closed by a flat plate of glass. A brass tube leading into the cavity served for connection with the hearing-tube. When this conical cavity was stuffed with worsted or other fibrous materials the sounds produced were much louder than when a test-tube was employed. This form of receiver is shown in Fig. 1.

Fig. 1.



Mr. Tainter next collected silks and worsteds of different colors, and speedily found that the darkest shades produced the best effects. Black worsted especially gave an extremely loud sound.

As white cotton-wool had proved itself equal, if not superior, to any other white fibrous material before tried, he was anxious to obtain colored specimens for comparison. Not having any at hand, however, he tried the effect of darkening some cotton-wool with lampblack.

* On the 7th of January.

Such a marked reënforcement of the sound resulted that he was induced to try lampblack alone.

About a teaspoonful of lampblack was placed in a test-tube and exposed to an intermittent beam of sunlight. The sound produced was much louder than any heard before.

Upon smoking a piece of plate-glass, and holding it in the intermittent beam with the lampblack surface toward the sun, the sound produced was loud enough to be heard, with attention, in any part of the room. With the lampblack surface turned from the sun, the sound was much feebler.

Mr. Tainter repeated these experiments for me immediately upon my return to Washington, so that I might verify his results.

Upon smoking the interior of the conical cavity shown in Fig. 1, and then exposing it to the intermittent beam, with the glass lid in position as shown, the effect was perfectly startling. The sound was so loud as to be actually painful to an ear placed closely against the end of the hearing-tube.

The sounds, however, were sensibly louder when we placed some smoked wire-gauze in the receiver, as illustrated in the drawing (Fig. 1).

When the beam was thrown into a resonator, the interior of which had been smoked over a lamp, most curious alternations of sound and silence were observed. The interrupting disk was set rotating at a high rate of speed, and was then allowed to come gradually to rest. An extremely feeble musical tone was at first heard, which gradually fell in pitch as the rate of interruption grew less. The loudness of the sound produced varied in the most interesting manner. Minor reënforcements were constantly occurring, which became more and more marked as the true pitch of the resonator was neared. When at last the frequency of interruption corresponded to the frequency of the fundamental of the resonator, the sound produced was so loud that it might have been heard by an audience of hundreds of people.

The effects produced by lampblack seemed to me to be very extraordinary, especially as I had a distinct recollection of experiments made in the summer of 1880 with smoked diaphragms, in which no such reënforcement was noticed.

Upon examining the records of our past photophonic experiments we found in vol. vii, p. 57, the following note :

> Experiment V.—Mica diaphragm covered with lampblack on side exposed to light.
>
> Result: distinct sound about same as without lampblack.—A. G. B., *July* 18, 1880.
>
> Verified the above, but think it somewhat louder than when used without lampblack.—S. T., *July* 18, 1880.

Upon repeating this old experiment we arrived at the same result as that noted. Little if any augmentation of sound resulted from

smoking the mica. In this experiment the effect was observed by placing the mica diaphragm against the ear, and also by listening through a hearing-tube, one end of which was closed by the diaphragm. The sound was found to be more audible through the free air when the ear was placed as near to the lampblack surface as it could be brought without shading it.

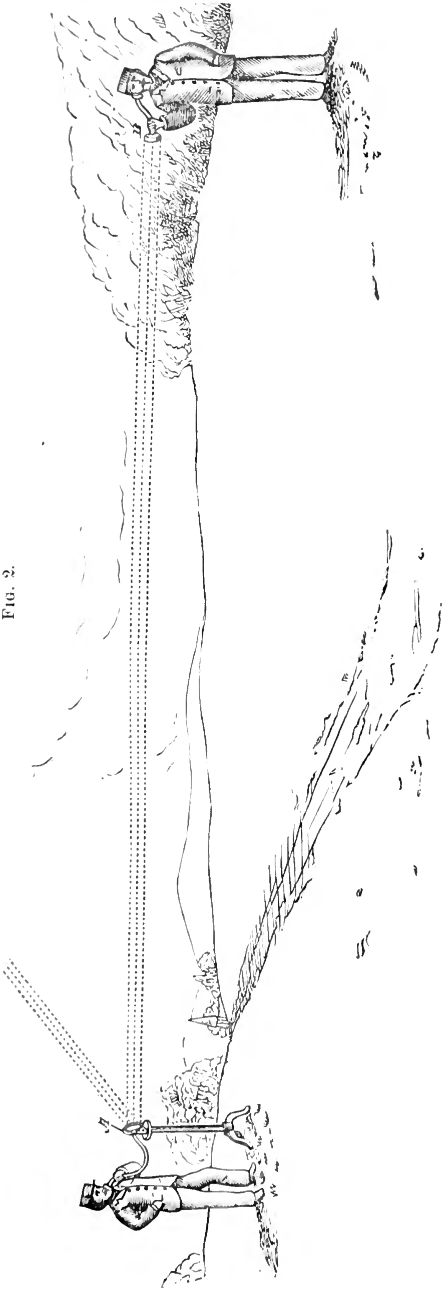


Fig. 2.

At the time of my communication to the American Association I had been unable to satisfy myself that the substances which had become sonorous under the direct influence of intermittent sunlight were capable of reproducing the sounds of articulate speech under the action of an undulatory beam from our photophonic transmitter. The difficulty in ascertaining this will be understood by considering that the sounds emitted by thin diaphragms and tubes were so feeble that it was impracticable to produce audible effects from substances in these conditions at any considerable distance away from the transmitter; but it was equally impossible to judge of the effects produced by our articulate transmitter at a short distance away, because the speaker's voice was directly audible through the air. The extremely loud sounds produced from lampblack have enabled us to demonstrate the feasibility of using this substance in an articulating photophone in place of the electrical receiver formerly employed.

The drawing (Fig. 2) illustrates the mode in which the ex-

periment was conducted. The diaphragm of the transmitter (A) was only five centimetres in diameter, the diameter of the receiver (B) was

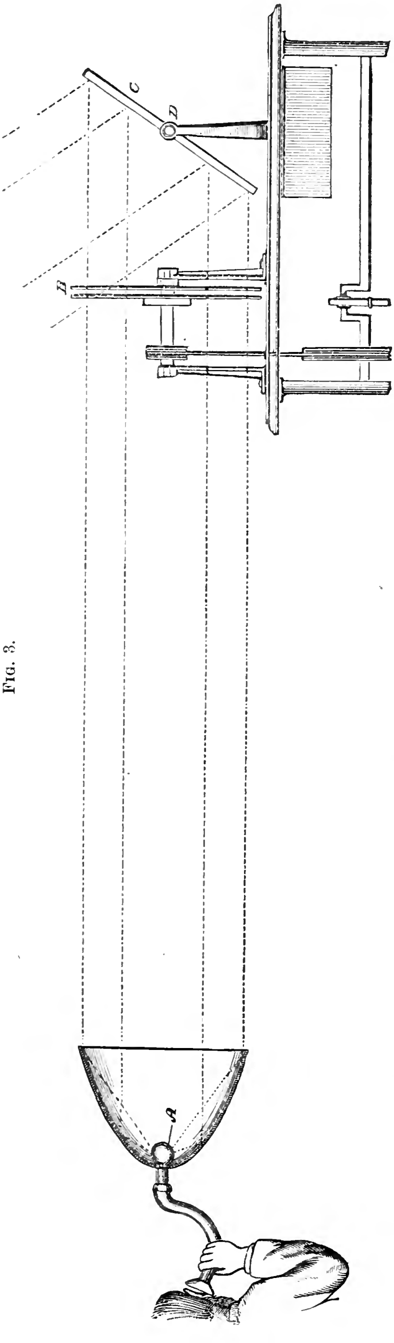
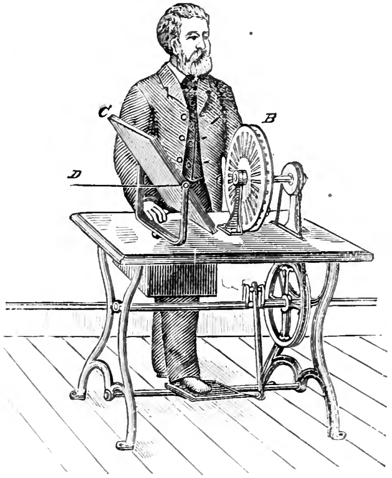


Fig. 3.



also five centimetres, and the distance between the two was forty metres, or eight hundred times the diameter of the transmitting diaphragm. We were unable to experiment at greater distances without a heliostat, on account of the difficulty of keeping the light steadily directed on the receiver. Words and sentences spoken into the transmitter in a low tone of voice were audibly reproduced by the lampblack receiver.

In Fig. 3 is shown a mode of interrupting a beam of sunlight for producing distant effects without the use of lenses. Two similarly-perforated disks are employed, one of which is set in rapid rotation, while the other remains stationary. This form of interrupter is also admirably adapted for work with artificial light. The receiver illustrated in the drawing consists of a parabolic reflector, in the focus of which is placed a glass vessel (A) containing lampblack or other sensitive substance, and connected with

a hearing-tube. The beam of light is interrupted by its passage through the two slotted disks shown at B, and in operating the instrument musical signals like the dots and dashes of the Morse alphabet are produced from the sensitive receiver (A) by slight motions of the mirror (C) about its axis (D).

In place of the parabolic reflector shown in the figure a conical reflector like that recommended by Professor Sylvanus Thompson* can be used, in which case a cylindrical glass vessel would be preferable to the flask (A) shown in the figure.

In regard to the sensitive materials that can be employed, our experiments indicate that in the case of solids the physical condition and the color are two conditions that markedly influence the intensity of the sonorous effects. *The loudest sounds are produced from substances in a loose, porous, spongy condition, and from those that have the darkest or most absorbent colors.*

The materials from which the best effects have been produced are cotton-wool, worsted, fibrous materials generally, cork, sponge, platinum, and other metals in a spongy condition, and lampblack.

The loud sounds produced from such substances may perhaps be explained in the following manner: Let us consider, for example, the case of lampblack—a substance which becomes heated by exposure to rays of all refrangibility. I look upon a mass of this substance as a sort of sponge, with its pores filled with air instead of water. When a beam of sunlight falls upon this mass, the particles of lampblack are heated, and consequently expand, causing a contraction of the air-spaces or pores among them.

Under these circumstances a pulse of air should be expelled, just as we would squeeze out water from a sponge.

The force with which the air is expelled must be greatly increased by the expansion of the air itself, due to contact with the heated particles of lampblack. When the light is cut off, the converse process takes place. The lampblack particles cool and contract, thus enlarging the air spaces among them, and the inclosed air also becomes cool. Under these circumstances a partial vacuum should be formed among the particles, and the outside air would then be absorbed, as water is by a sponge when the pressure of the hand is removed.

I imagine that in some such manner as this a wave of condensation is started in the atmosphere each time a beam of sunlight falls upon lampblack, and a wave of rarefaction is originated when the light is cut off. *We can thus understand how it is that a substance like lampblack produces intense sonorous vibrations in the surrounding air, while at the same time it communicates a very feeble vibration to the diaphragm or solid bed upon which it rests.*

This curious fact was independently observed in England by Mr. Preece, and it led him to question whether, in our experiments with

* "Philosophical Magazine," April, 1881, vol. xi, p. 286.

thin diaphragms, the sound heard was due to the vibration of the disk or (as Professor Hughes had suggested) to the expansion and contraction of the air in contact with the disk confined in the cavity behind the diaphragm. In his paper read before the Royal Society on the 10th of March, Mr. Preece describes experiments from which he claims to have proved that the effects are wholly due to the vibrations of the confined air, and that the *disks do not vibrate at all.*

I shall briefly state my reasons for disagreeing with him in this conclusion :

1. When an intermittent beam of sunlight is focused upon a sheet of hard rubber or other material, a musical tone can be heard, not only by placing the ear immediately behind the part receiving the beam, but by placing it against any portion of the sheet, even though this may be a foot or more from the place acted upon by the light.

2. When the beam is thrown upon the diaphragm of a "Blake transmitter," a loud musical tone is produced by a telephone connected in the same galvanic circuit with the carbon button (A), Fig. 4. Good effects are also produced when the carbon button (A) forms, with the battery (B), a portion of the primary circuit of an induction-coil, the telephone (C) being placed in the secondary circuit.

In these cases the wooden box and mouth-piece of the transmitter should be removed, so that no air-cavities may be left on either side of the diaphragm.

It is evident, therefore, that in the case of thin disks a real vibration of the diaphragm is caused by the action of the intermittent beam, independently of any expansion and contraction of the air confined in the cavity behind the diaphragm.

Lord Rayleigh has shown mathematically that a to-and-fro vibration, of sufficient amplitude to produce an audible sound, would result from a periodical communication and abstraction of heat, and he says : "We may conclude, I think, that there is at present no reason for discarding the obvious explanation that the sounds in question are due to the bending of the plates under unequal heating" ("Nature," vol. xxiii, p. 274). Mr. Preece, however, seeks to prove that the sonorous effects can not be explained upon this supposition ; but his experimental proof is inadequate to support his conclusion. Mr. Preece expected that, if Lord Rayleigh's explanation was correct, the expansion and contraction of a thin strip under the influence of an intermittent beam could be caused to open and close a galvanic circuit so as to produce a musical tone from a telephone in the circuit. But this was an inadequate way to test the point at issue, for Lord Rayleigh has shown ("Proceedings of the Royal Society," 1877) that an audible sound can be produced by a vibration whose amplitude is *less than a ten-millionth of a centimetre,* and certainly such a vibration as that would not have sufficed to operate a "make-and-break contact" like that used by Mr. Preece. The negative results obtained by him can not, therefore, be considered conclusive.

The following experiments (devised by Mr. Tainter) have given re-

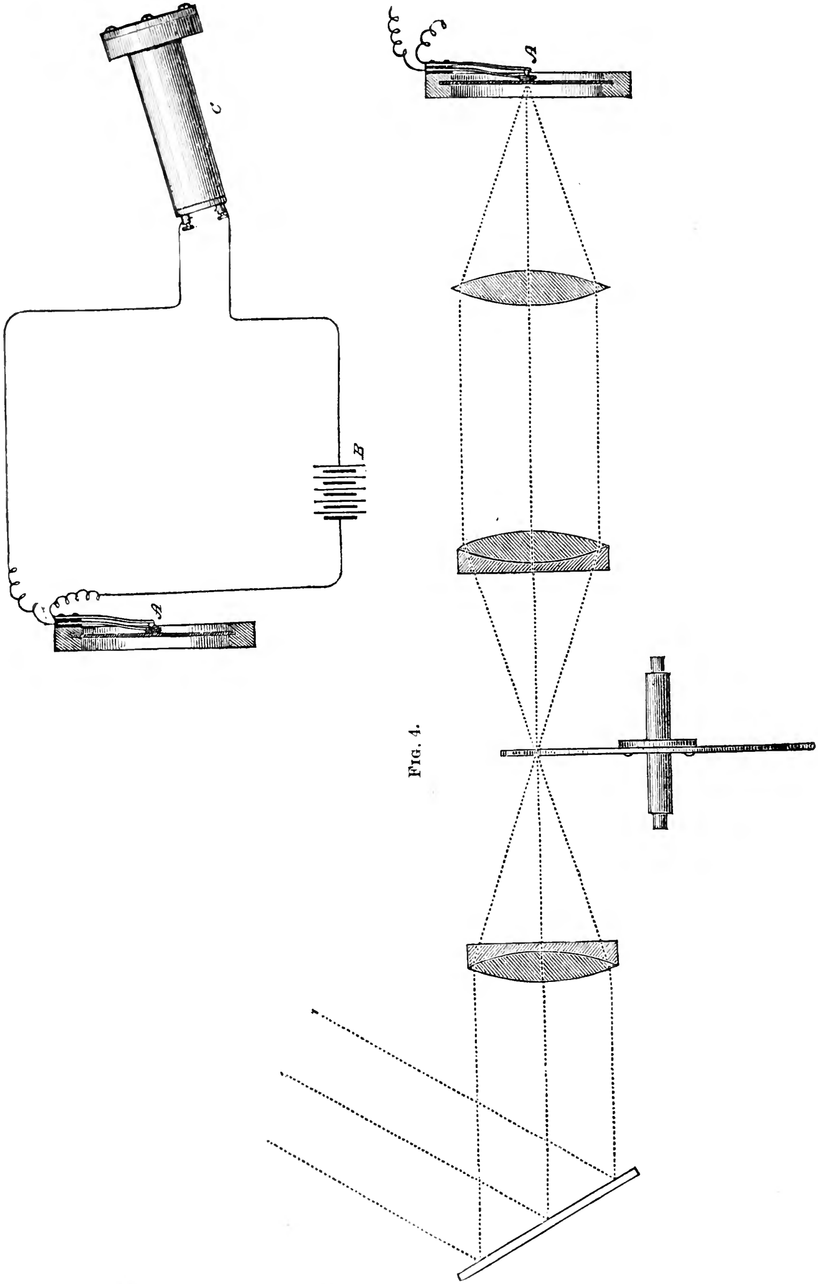


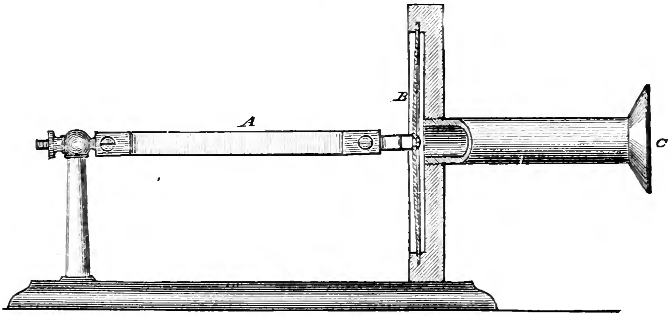
FIG. 4.

sults decidedly more favorable to the theory of Lord Rayleigh than to that of Mr. Preece:

1. A strip (A) similar to that used in Mr. Preece's experiment was attached firmly to the center of an iron diaphragm (B), as shown in Fig. 5, and was

then pulled taut at right angles to the plane of the diaphragm. When the intermittent beam was focused upon the strip (A), a clear musical tone could be heard by applying the ear to the hearing-tube (C).

FIG. 5.



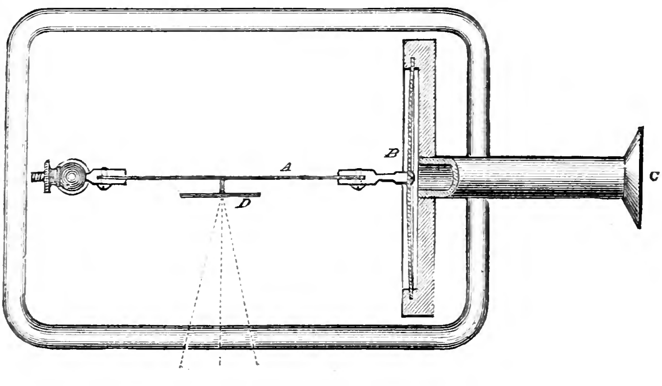
This seemed to indicate a rapid expansion and contraction of the substance under trial.

But a vibration of the diaphragm (B) would also have resulted if the thin strip (A) had acquired a to-and-fro motion, due either to the direct impact of the beam or to the sudden expansion of the air in contact with the strip.

2. To test whether this had been the case, an additional strip (D) was attached by its central point only to the strip under trial, and was then submitted to the action of the beam, as shown in Fig. 6.

It was presumed that, if the vibration of the diaphragm (B) had been due to a *pushing force* acting on the strip (A), the addition of the strip (D) would not interfere with the effect; but, if, on the other hand, it had been due to the longitudinal expansion and contraction of the strip (A), the sound would cease, or at least be reduced. The beam of light falling upon the strip (D) was now interrupted as before by the rapid rotation of a perforated disk, which was allowed to come gradually to rest.

FIG. 6.



No sound was heard excepting at a certain speed of rotation, when a feeble musical tone became audible.

This result is confirmatory of the first.

The audibility of the effect at a particular rate of interruption suggests the explanation that the strip D had a normal rate of vibration of its own.

When the frequency of the interruption of the light corresponded to this, the strip was probably thrown into vibration after the manner of a tuning-fork, in which case a to-and-fro vibration would be propagated down its stem or central support to the strip (A).

This indirectly proves the value of the experiment.

The list of solid substances that have been submitted to experiment in my laboratory is too long to be quoted here, and I shall merely say that we have not yet found one solid body that has failed to become sonorous under proper conditions of experiment.*

Experiments with Liquids.—The sounds produced by liquids are much more difficult to observe than those produced by solids. The high absorptive power possessed by most liquids would lead one to expect intense vibrations from the action of intermittent light; but the number of sonorous liquids that have so far been found is extremely limited, and the sounds produced are so feeble as to be heard only by the greatest attention and under the best circumstances of experiment. In the experiments made in my laboratory, a very long test-tube was filled with the liquid under examination, and a flexible rubber tube was slipped over the mouth far enough down to prevent the possibility of any light reaching the vapor above the surface. Precautions were also taken to prevent reflection from the bottom of the test-tube. An intermittent beam of sunlight was then focused upon the liquid in the middle portion of the test-tube by means of a lens of large diameter.

RESULTS.

Clear water	No sound audible.
Water discolored by ink	Feeble sound.
Mercury	No sound heard.
Sulphuric ether*	Feeble but distinct sound.
Ammonia	" " " "
Ammonio-sulphate of copper	" " " "
Writing-ink	" " " "
Indigo in sulphuric acid	" " " "
Chloride of copper*	" " " "

The liquids distinguished by an asterisk gave the best sounds.

Acoustic vibrations are always much enfeebled in passing from liquids to gases, and it is probable that a form of experiment may be devised which will yield better results by communicating the vibrations of the liquid to the ear through the medium of a solid rod.

* Carbon and thin microscope-glass are mentioned in my Boston paper as non-responsive, and powdered chlorate of potash in the communication to the French Academy ("Comptes Rendus," vol. cxl, p. 595). All these substances have since yielded sounds under more careful conditions of experiment.

Experiments with Gaseous Matter.—On the 29th of November, 1880, I had the pleasure of showing to Professor Tyndall, in the laboratory of the Royal Institution, the experiments described in the letter to Mr. Tainter from which I have quoted above; and Professor Tyndall at once expressed the opinion that the sounds were due to rapid changes of temperature in the body submitted to the action of the beam. Finding that no experiments had been made at that time to test the sonorous properties of different gases, he suggested filling one test-tube with the vapor of sulphuric ether (a good absorbent of heat), and another with the vapor of bisulphide of carbon (a poor absorbent), and he predicted that if any sound were heard it would be louder in the former case than in the latter.

The experiment was immediately made, and the result verified the prediction.

Since the publication of the memoirs of Röntgen * and Tyndall † we have repeated these experiments, and have extended the inquiry to a number of other gaseous bodies, obtaining in every case similar results to those noted in the memoirs referred to.

The vapors of the following substances were found to be highly sonorous in the intermittent beam: Water-vapor, coal-gas, sulphuric ether, alcohol, ammonia, amylene, ethyl bromide, diethylamene, mercury, iodine, and peroxide of nitrogen. The loudest sounds were obtained from iodine and peroxide of nitrogen.

I have now shown that sounds are produced by the direct action of intermittent sunlight from substances in every physical condition (solid, liquid, and gaseous), and the probability is, therefore, very greatly increased that sonorousness under such circumstances will be found to be a universal property of matter.

[*To be continued.*]

THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

By HERBERT SPENCER.

VII.—COMPOUND POLITICAL HEADS.

IN the preceding chapter on chiefs and kings, we traced the development of the first element in that triune political structure which everywhere shows itself at the outset. We pass now to the development of the second element—the group of leading men among whom the chief is, at first, merely the most conspicuous. Under what conditions this so evolves as to subordinate the other two, what causes

* "Annalen der Physik und Chemie," 1881, No. 1, p. 155.

† "Proceedings of the Royal Society," vol. xxxi, p. 307.

make it narrower, and what causes widen it until it passes into the third, we have here to observe.

If the innate feelings and aptitudes of a race have large shares in determining the size and cohesions of the social groups it forms, still more must they have large shares in determining the relations which arise among the members of such groups. While the mode of life followed tends to generate this or that political structure, its effects are always complicated by the effects of inherited character. Whether or not the primitive state, in which governing power is equally distributed among all warriors or all elders, passes into the state in which governing power is monopolized by one, depends, in part, on the life of the group as predatory or peaceful, and in part on the natures of its members as prompting them to oppose dictation more or less doggedly. A few facts will make this clear.

The Arafuras (Papuan-Islanders) who "live in peace and brotherly love," have no other "authority among them than the decisions of their elders." Among the harmless Todas "all disputes and questions of right and wrong are settled either by arbitration or by a Punchayet—i. e., a council of five." Of the Bodo and Dhimáls, described as averse to military service, and "totally free from arrogance, revenge, cruelty, and *fierté*," we read that though each of their small communities has a nominal head who pays the tribute on its behalf, yet he is without power, and "disputes are settled among themselves by juries of elders." In these cases, besides absence of the causes which bring about chiefly supremacy, may be noted the presence of causes which directly hinder it. The Papuans generally, typified by the Arafuras above named, while they are described by Modera, Ross, and Kolff, as "good-natured," "of a mild disposition," kind and peaceful to strangers, are said by Earl to be unfit for military action; "their impatience of control . . . utterly precludes that organization which would enable" the Papuans "to stand their ground against encroachments." The Bodo and Dhimáls while "they are void of all violence toward their own people or toward their neighbors," also "resist injunctions, injudiciously urged, with dogged obstinacy." And of a kindred "very fascinating people," the Lepchas, amiable, peaceful, kind, as travelers unite in describing them, and who will not take service as soldiers, we are told that they will "undergo great privation rather than submit to oppression or injustice."

Where the innate tendency to resist coercion is strong, we find this uncentralized political organization maintained, notwithstanding the warlike activities which tend to initiate settled chieftainship. The Nagas "acknowledge no king among themselves, and deride the idea of such a personage among others"; their "villages are continually at feud"; "every man being his own master, his passions and inclinations are ruled by his share of brute force." And then we further find that "petty disputes and disagreements about property are settled

by a council of elders, the litigants voluntarily submitting to their arbitration. But, correctly speaking, there is not the shadow of a constituted authority in the Naga community, and, wonderful as it may seem, this want of government does not lead to any marked degree of anarchy and confusion." Similarly among such peoples, remote in type, as many of the warlike tribes of North America. Speaking of these Indians in general, Schoolcraft says that "they all wish to govern, and not to be governed. Every Indian thinks he has a right to do as he pleases, and that no one is better than himself; and he will fight before he will give up what he thinks right." Of the Comanches, as an example, he remarks that "the democratic principle is strongly implanted in them"; and that for governmental purposes "public councils are held at regular intervals during the year." Further, we read that in districts of ancient Central America there existed somewhat more advanced societies which, though warlike, were impelled by a kindred jealousy to provide against monopoly of power. The government was by an elective council of old men who appointed a war-chief; and this war-chief, "if suspected of plotting against the safety of the commonwealth, or for the purpose of securing supreme power in his own hands, was rigorously put to death by the council."

Though the specialities of character which thus lead certain kinds of men in early stages to originate compound political headships, and to resist, even under the stress of war, the rise of single political headships, are innate, we are not without clews to the circumstances which have made them innate; and, with a view to interpretations presently to be made, it will be useful to glance at these. The Comanches and kindred tribes, roaming about in small bands, active and skillful horsemen, have, through long-past periods, been so conditioned as to make coercion of one man by another difficult. So, too, has it been, though in another way, with the Nagas. "They inhabit a rough and intricate mountain-range"; and their villages are perched "on the crests of ridges." Again, very significant evidence is furnished by an incidental remark of Captain Burton to the effect that in Africa, as in Asia, there are three distinctly marked forms of government—military despotisms, feudal monarchies, and rude republics; the rude republics being those formed by "the Bedouin tribes, the hill people, and the jungle races." Clearly, the names of these last show that they inhabit regions which, hindering by their physical characters a centralized form of government, favor a more diffused form of government, and the less decided political subordination which is its concomitant.

These facts are obviously related to certain other facts with which they must be joined. Already evidence has been given that it is relatively easy to form a large society if the country is one within which all parts are readily accessible, while it has barriers through which exit is difficult; and that, conversely, formation of a large society is prevented, or greatly delayed, by difficulties of communication within

the occupied area, and by facilities of escape from it. But, as we now see, not only is political integration under its primary aspect of increasing mass hindered by these last-named physical conditions, but there is hindrance to the development of a more integrated form of government. That which impedes social consolidation also impedes the concentration of political power.

The truth here chiefly concerning us, however, is that the continued presence of the one or the other set of conditions fosters a character to which either the centralized or the diffused kind of political organization is appropriate. Existence, generation after generation, in a region where despotic control has arisen, produces an adapted type of nature; partly by daily habit and partly by survival of those most fit for living under such control. Contrariwise, in a region favoring maintenance of their independence by small groups, there is a strengthening, through successive ages, of sentiments averse to restraint; since not only are these sentiments exercised in all by resisting the efforts from time to time made to subordinate them, but, on the average, those who most pertinaciously resist are those who, remaining unsubdued, and transmitting their characters to posterity, determine the tribal character.

Having thus glanced at the effects of the factors, external and internal, as displayed in simple tribes, we shall understand how they coöperate when, by migration or otherwise, such tribes fall into circumstances which favor the growth of large societies.

The case of an uncivilized people of the nature described, who have in recent times shown what occurs when union of small groups into great ones is prompted, will best initiate the interpretation.

The Iroquois nations, each made up of many tribes previously hostile, had to defend themselves against European invaders. Combination for this purpose among these five (and finally six) nations necessitated a recognition of equality of power among them; since agreement to join would not have been arrived at had it been required that some divisions should be subject to others. The groups had to coöperate on the understanding that their "rights, privileges, and obligations" should be the same. Though the numbers of permanent and hereditary sachems appointed by the respective nations to form the Great Council, differed, yet the voices of the several nations were equal. Omitting details of the organization, we have to note first, that for many generations, notwithstanding the wars which this league carried on, its constitution remained stable—no supreme individual arose; and, second, that this equality of power among the groups coexisted with inequality within each group: the people had no share in its government.

A clew is thus furnished to the genesis of those compound headships with which ancient history familiarizes us. We are enabled to

see how there came to coexist, in the same societies, some institutions of a despotic kind, with other institutions of a kind appearing to be based on the principle of equality, and often confounded with free institutions. Let us recall the antecedents of those early European peoples who developed governments of this form.

During the wandering pastoral life, subordination to a single head, growing naturally out of fatherhood, was fostered. A recalcitrant member of any group had either to submit to the authority under which he had grown up, or, throwing off its yoke, had to leave the group and face those risks which unprotected life in the desert threatened. The establishment of this subordination was furthered by the more frequent survival of groups in which it was greatest; since, in the conflicts between groups, those of which the members were insubordinate, ordinarily being both smaller and less able to coöperate effectually, were the more likely to disappear. But now, to the fact that in such families and clans circumstances fostered obedience to the father and to the patriarch, has to be added the fact above emphasized, that circumstances also fostered the sentiment of liberty in the relations between clans. The exercise of power by one of them over another was made difficult by wide scattering and by great mobility; and with successful opposition to external coercion, or evasion of it, carried on through numberless generations, the tendency to resent and resist all strange authority was likely to become strong.

Whether, when groups thus disciplined aggregate, they assume this or that form of political organization, depends partly, as already implied, on the conditions into which they fall. Even could we omit those differences between Mongols, Semites, and Aryans, established in prehistoric times by causes unknown to us—even had complete likeness of nature been produced in them by long continuance of pastoral life—yet large societies, formed by combinations of these small ones, could be similar in type only under similar circumstances. Hence, probably, the reason why Mongols and Semites, where they have settled and multiplied, have failed to maintain the autonomies of their hordes after combination of them, and to evolve the resulting institutions. Even the Aryans, among whom chiefly the less concentrated forms of political rule have arisen, yield an illustration. Originally inheriting in common the mental traits generated during their life in the Hindoo-Koosh and its neighborhood, the different divisions of the race have developed different institutions and accompanying characters. Those of them who spread into the plains of India, where great fertility made possible a large population, to the control of which there were small physical impediments, lost their independence of nature, and did not evolve political systems like those which grew up among their Western kindred, under conditions favorable for maintaining the original character.

The implication is, then, that where groups of the patriarchal type

fall into regions permitting considerable growth of population, but having physical structures which impede the centralization of power, compound political headships will arise, and for a time sustain themselves, through coöperation of the two factors—independence of local groups and need for union in war. Let us consider some examples.

The island of Crete has numerous high mountain-valleys containing good pasturage, and provides many seats for strongholds—seats which ruins prove that the ancient inhabitants utilized. Similarly with the mainland of Greece. A complicated mountain system cuts off its parts from one another and renders each difficult of access. Especially is this so in the Peloponnesus; and, above all, in the part occupied by the Spartans. It has been remarked that the state which possesses both sides of Taygetus has it in its power to be master of the peninsula: "It is the Acropolis of the Peloponnese, as that country is of the rest of Greece."

When, over the earlier inhabitants, there came the successive waves of Hellenic conquerors, these brought with them the type of nature and organization common to the Aryans, displaying the united traits above described. Such a people, taking possession of such a land, inevitably fell in course of time "into as many independent clans as the country itself was divided by its mountain-chains into valleys and districts." From separation there resulted alienation; so that those remote from one another, becoming strangers, became enemies. In early Greek times the clans, occupying mountain villages, were so liable to incursions from one another that the planting of fruit-trees was a waste of labor. There existed a state like that seen at present among such Indian hill tribes as the Nagas.

Though preserving the tradition of a common descent, and owning allegiance to the oldest male representative of the patriarch, a people spreading over a region which thus cut off from one another even adjacent small groups, and still more those remoter clusters of groups arising in course of generations, would inevitably become disunited in government: subjection to a general head would be more and more difficult to maintain, and subjection to local heads would alone continue practicable. Moreover, there must arise, under such conditions, increasing causes of insubordination, as well as great difficulties in maintaining subordination. When the various branches of a common family spread into localities so shut off from one another as to prevent intercourse, their respective histories, and the lines of descent of their respective heads, must become unknown, or but partially known, to one another; and claims to supremacy made now by this local head and now by that are certain to be disputed. When we remember how, even in settled societies having records, there have been perpetual conflicts about rights of succession, and how, down to our own day, there are frequent lawsuits to decide on heirships to titles and proper-

ties, we can not but infer that, in a state like that of the early Greeks, the difficulty of establishing the legitimacy of general headships, conspiring with the desire to assert independence and the ability to maintain it, inevitably entailed lapse into numerous local headships. Of course, under conditions varying in each locality, splittings-up of wider governments into narrower went to different extents; and, naturally, too, reëstablishments of wider governments or extensions of narrower ones in some cases took place. But, generally, the tendency under such conditions must have been to form small independent groups, severally having the patriarchal type of organization. Hence, then, the decay of such kingships as are implied in the "Iliad." As Grote writes, "When we approach historical Greece, we find that (with the exception of Sparta) the primitive, hereditary, unresponsible monarch, uniting in himself all the functions of government, has ceased to reign." *

But now what will happen when a cluster of clans of common descent, which have become independent and hostile, are simultaneously endangered by enemies to whom they are not at all akin, or but remotely akin? Habitually, they will sink their differences and coöperate for defense. But on what terms will they coöperate? Even among friendly groups joint action would be hindered if some claimed supremacy; and, among groups having outstanding feuds, there could be no joint action save on a footing of equality. The common defense would, therefore, be directed by a body formed of the heads of the coöperating small societies; and, if the coöperation for defense were prolonged, or became changed by success into coöperation for offense, this temporary controlling body would tend to become a permanent one holding the small societies together. The special characters of this compound head would, of course, vary with the circumstances. Where the traditions of the united clans agreed in identifying some one chief as the lineal representative of the original patriarch or hero, from whom all descended, precedence and some extra authority would

* While I am writing, the just-issued third volume of Mr. Skene's "Celtic Scotland" supplies me with an instructive illustration of the process above indicated. From his account it appears that the original Celtic tribes which formed the earldoms of Moray, Buchan, Athol, Angus, Menteith, became broken up into clans; and how influential was the physical character of the country in producing this result, we are shown by the fact that this change took place in the parts of them which fell within the Highland country. Describing the smaller groups which resulted, Mr. Skene says: "While the clan, viewed as a single community, thus consisted of the chief, with his kinsmen to a certain limited degree of relationship; the commonalty who were of the same blood, who all bore the same name, and his dependents, consisting of subordinate septs of native men, who did not claim to be of the blood of the chief, but were either probably descended from the more ancient occupiers of the soil, or were broken men from other clans, who had taken protection with him. . . . Those kinsmen of the chief who acquired the property of their land founded families. . . . The most influential of these was that of the oldest cadet in the family which had been longest separated from the main stem, and usually presented the appearance of a rival house little less powerful than that of the chief."

be permitted to him. Where claims derived from descent were disputed, personal superiority or election would determine which member of the compound head should take the lead. If within each of the component groups the power of its chief was unqualified, there would result from union of such chiefs a close oligarchy; while the closeness of the oligarchy would become less in proportion as recognition of the authority of each chief, given by nearness in blood to the divine or semi-divine ancestor, diminished. And in cases where there came to be incorporated numerous aliens, owing allegiance to the heads of none of the component groups, there would come into play influences tending still more to widen the oligarchy.

Such, we may conclude, were the origins of those compound headships of the Greek states which existed at the beginning of the historic period. In Crete, where there survived the tradition of primitive kingship, but where dispersion and subdivision of clans had brought about a condition in which "different towns carried on open feuds," there were "patrician houses, deriving their rights from the early ages of royal government," who continued "to retain possession of the administration." In Corinth, the line of Herakleid kings "subsides gradually, through a series of empty names, into the oligarchy denominated Bacchiadæ. . . . The persons so named were all accounted descendants of Herakles, and formed the governing caste in the city." So was it with Megara. According to tradition, this arose by combination of several villages inhabited by kindred tribes, which, originally in antagonism with Corinth, had probably, in the course of this antagonism, become consolidated into an independent state. And at the opening of the historic period the like had happened in Sikyon and other places. Though in Sparta kingship had survived under an anomalous form, yet the joint representatives of the primitive king, still reverenced because the tradition of their divine descent was preserved, had become little more than members of the governing oligarchy, retaining certain prerogatives. And, though it is true that in its earliest historically-known stage, the Spartan oligarchy did not present the form which would spontaneously arise from the union of the heads of clans for coöperation in war—though it had become elective within a limited class of persons—yet the fact that an age of not less than sixty was a qualification, harmonizes with the belief that it at first consisted of the heads of the respective groups, who were always the eldest sons of the eldest; and that these groups with their heads, described as having been in in pre-Lykurgean times "the most lawless of all the Greeks," became united by that continuous militant life which distinguished them.*

* As bearing on historical interpretations at large, and especially on interpretations to be made in this work, let me point out further reasons than those given by Grote and others for rejecting the tradition that the Spartan constitution was the work of Lykurgus. The universal tendency to ascribe an effect to the most conspicuous proximate cause is

The Romans exemplify the rise of a compound headship under conditions which, though partially different from those the Greeks were subject to, were allied fundamentally. In its earliest-known state, Latium was occupied by village-communities, which were united into cantons; while these cantons formed a league headed by Alba—a canton regarded as the oldest and most eminent. This combination was for joint defense; as is shown by the fact that each group of clan-villages composing a canton had an elevated stronghold in common, and also by the fact that the league of cantons had for its center and place of refuge Alba, the most strongly placed as well as the oldest. The component cantons of the league were so far independent that there were wars between them; whence we may infer that when they co-operated for joint defense it was on substantially equal terms. Thus, before Rome existed, the people who formed it had been habituated to a kind of life such that, with great subordination in each family and clan, and partial subordination within each canton (which was governed by a prince, council of elders, and assembly of warriors), there went a union of heads of cantons, who were in no degree subordinate one to another. When the inhabitants of three of these cantons, the Ramnians, Tities, and Luceres, began to occupy the tract on which Rome stands, they brought with them their political organization. The oldest Roman patricians bore the names of rural clans belonging to these cantons. Whether, when seating themselves on the Palatine Hills and on the Quirinal, they preserved their cantonal divisions, is not clear, though it seems probable *a priori*. But, however this may be, there is proof that they fortified themselves against one another, as

especially strong where the effect is one of which the causation is involved. Our own time has furnished an illustration in the ascription of Corn-law Repeal to Sir Robert Peel, and after him to Messrs. Cobden and Bright, leaving Colonel Thompson unnamed. In the next generation the man who for a time carried on the fight single-handed, and forged sundry of the weapons used by the victors, will be unheard of in connection with it. It is not enough, however, to suspect that Lykurgus was simply the finisher of other men's work. We may reasonably suspect that the work was that of no man, but simply that of the needs and conditions. This may be seen in the institution of the public mess. If we ask what will happen with a small people who, for generations spreading as conquerors, have a contempt for all industry, and who, when not at war, pass their time in exercises fitting them for war, it becomes manifest that at first the daily assembling to carry on these exercises will entail the daily bringing of provisions by each. As happens in those picnics in which all who join contribute to the common repast, a certain obligation respecting qualities and quantities will naturally arise—an obligation which, repeated daily, will pass from custom into law; ending in a specification of the kinds and amounts of food. Further, it is to be expected that as the law thus arises in an age when food is coarse and unvaried, the simplicity of the diet, originally unavoidable, will eventually be considered as intended—as an ascetic regimen deliberately devised. (When writing this I was not aware that, as pointed out by Professor Paley in "Fraser's Magazine," for February, 1881, that among the Greeks of later times it was common to have dinners to which each guest brought his share of provisions, and that those who contributed little and consumed much were objects of satire. This fact greatly increases the probability that the Spartan mess originated as suggested.)

well as against outer enemies. The "mount-men" of the Palatine and the "hill-men" of the Quirinal were habitually at feud; and, even among the minor divisions of those who occupied the Palatine, there were dissensions. As Mommsen says, primitive Rome was "rather an aggregate of urban settlements than a single city." And that the clans who formed these settlements brought with them their enmities is to be inferred from the fact that not only did they fortify the hills on which they fixed themselves, but even "the houses of the old and powerful families were constructed somewhat after the manner of fortresses."

So that again, in the case of Rome, we a see a cluster of small independent communities allied in blood but partially antagonistic, which had to coöperate against enemies on such terms as all would agree to. In early Greece the means of defense were, as Grote remarks, greater than the means of attack; and it was the same in early Rome. Hence, while coercive rule within each family and small group was easy, there was difficulty in extending coercion over many groups—fortified as they were against one another. Moreover, the stringency of government within each settlement constituting the primitive city was diminished by facility of escape from one and admission into another. As we have seen among simple tribes, desertions take place when the rule is unduly harsh; and we may infer that, within each of these clustered settlements, there was a check on exercise of force by the heads of the more powerful families over those of the less powerful, caused by the fear that migration might weaken the settlement and strengthen an adjacent one. Thus the circumstances were such that when, for defense of the primitive city, coöperation became needful, the heads of the clans included in the several settlements came to have substantially equal powers. The original senate was the collective body of clan-elders; and "this assembly of elders was the ultimate holder of the ruling power": it was "an assembly of kings." At the same time, the heads of families in each clan, forming the body of burgesses, stood, for like reasons, on equal footing. Primarily for command in war, there was an elected head, who was also chief magistrate. Though not having the authority given by alleged divine descent, he had the authority given by supposed divine approval; and, himself bearing the insignia of a god, he retained till death the absoluteness appropriate to one. But, besides the fact that the choice, originally made by the senate, had to be again practically made by it in case of sudden vacancy, and besides the fact that each king, nominated by his predecessor, had to be approved by the assembled burgesses, there is the fact that his power was exclusively executive. The assembly of burgesses "was in law superior to, rather than coördinate with, the king." Further, in the last resort was exercised the still superior power of the senate, which was the guardian of the law, and could veto the joint decision of king and burgesses. Thus the con-

stitution was in essence an oligarchy of heads of clans, included in an oligarchy of heads of houses—a compound oligarchy which became unqualified when kingship was suppressed. And here should be emphasized the truth, sufficiently obvious and yet continually ignored, that the Roman Republic, which remained when the regal power ended, was quite alien in nature to those popular governments with which it has been commonly classed. The heads of clans, of which the narrower governing body was formed, as well as the heads of families which formed the wider governing body, were, indeed, jealous of one another's powers ; and in so far simulated the citizens of a free state who individually maintain their equal rights. But these heads severally exercised unlimited powers over the members of their households and over their clusters of dependents. A community of which the component groups severally retained their internal autonomies, with the result that the rule within each remained absolute, was nothing but an aggregate of small despotisms. Institutions under which the head of each group, besides owning slaves, had such supremacy that his wife and children, including even married sons, had no more legal rights than cattle, and were at his mercy in life and limb, or could be sold into slavery, can be called free institutions only by those who confound similarity of external outline with similarity of internal structure.*

The formation of compound political heads in later times repeats this process in essentials, if not in details. In one way or other the result arises when a common need for defense compels coöperation, while there exists no means of securing coöperation save voluntary agreement.

Beginning with the example of Venice, we notice first that the region occupied by the ancient Veneti included the extensive marshy tract formed of the deposits brought down by several rivers to the Adriatic—a tract which, in Strabo's day, was "intersected in every quarter by rivers, streams, and morasses" ; so that "Aquileia and Ravenna were then cities in the marshes." Having for their stronghold this region full of spots accessible only to inhabitants who knew the intricate ways to them, the Veneti maintained their independence, spite of the efforts of the Romans to subdue them, until the days of Cæsar. In later days kindred results were more markedly displayed in that part of this region specially characterized by inaccessibility. From the earliest times the islets, or rather mud-banks, on which Venice stands, were inhabited by a maritime people. Each islet, secure in the midst of its tortuous lagunes, had a popular gov-

* I should have thought it needless to insist on so obvious a truth, had it not been that even still there continues this identification of things so utterly different. Within these few years has been published a magazine-article by an historian, describing the corruptions of the Roman Republic during its latter days, with the appended moral that such were, and are, likely to be the results of democratic government.

ernment of annually elected tribunes. And these original governments, existing at the time when there came several thousands of fugitives, driven from the mainland by the invading Huns, survived under the form of a rude confederation. As we have seen happen in other cases, the union into which these independent little communities were forced for purposes of joint defense was disturbed by feuds; and it was only under the stress of opposition to aggressing Lombards on the one side and Slavonic pirates on the other that a general assembly of nobles, clergy, and citizens appointed a duke or doge to direct the combined forces, and to restrain internal factions; being superior to the tribunes of the united islets and subject only to this body which appointed him. What changes subsequently took place—how, beyond the restraints imposed by the general assembly, the doge was presently put under the check of two elected councilors, and on important occasions had to summon the principal citizens; how there came afterward a representative council, which underwent from time to time changes—does not now concern us. Here we have simply to note that, as in preceding cases, the component groups being favorably circumstanced for severally maintaining their independence of one another, the imperative need for union against enemies initiated a rude compound headship, which, notwithstanding the centralizing effects of war, tended to maintain itself in one or other form.

On finding allied results among men of a different race but occupying a similar region, doubts respecting the process of causation must be dissipated. On the area—half land, half sea—formed of the sediment brought down by the Rhine and adjacent rivers, there early existed scattered families. Living on isolated sand-hills, or in huts raised on piles, they were so secure amid their creeks and mud-banks and marshes, that they remained unsubdued by the Romans. Subsisting at first by fishing, with here and there such small agriculture as was possible, and eventually becoming maritime and commercial, these people, in course of time, rendered their land more habitable by damming out the sea; and they long enjoyed a partial if not complete independence. In the third century "the Low Countries contained the only free people of the German race." Especially the Frisians, more remote than the rest from invaders, "associated themselves with the tribes settled on the limits of the German Ocean, and formed with them a connection celebrated under the title of the 'Saxon League.'" Though, at a later time, the inhabitants of the Low Countries fell under the power of France, yet the nature of their habitat continued to give them such advantages in resisting foreign control that they organized themselves after their own fashion, notwithstanding interdicts. "From the time of Charlemagne the people of the ancient Menapia, now become a prosperous commonwealth, formed political associations to raise a barrier against the despotic violence of the Franks." Mean-

while the Frisians, who, after centuries of resistance to the Franks, were obliged to yield and render small tributary services, retained their internal autonomy. They formed "a confederation of rude but self-governed maritime provinces," each of these seven provinces being divided into districts severally governed by elective heads with their councils, and the whole being under a general elective head and a general council.

Of illustrations which modern times have furnished, must be named those which again show us the effects of a mountainous region. The most notable is, of course, that of Switzerland. Surrounded by forests, "among marshes and rocks and glaciers, tribes of scattered shepherds had, from the early times of the Roman conquest, found a land of refuge from the successive invaders of the rest of Helvetia." In the labyrinths of the Alps, accessible to those only who knew the ways to them, their cattle fed unseen; and against straggling bands of marauders who might discover their retreats they had great facilities for defense. These districts—which eventually became the cantons of Schwytz, Uri, and Unterwalden, originally having but one common center of meeting, but eventually, as population increased, getting three, and forming separate political organizations—long preserved complete independence. With the spread of feudal subordination throughout Europe, they became nominally subject to the Emperor; but, refusing obedience to the superiors set over them, they entered into a solemn alliance, renewed from time to time, to resist outer enemies. Details of their history need not detain us. The fact of moment is, that in these three cantons, which physically favored in so great a degree the maintenance of independence by individuals and by groups, the people, while framing for themselves free governments, united on equal terms for joint defense. And it was these typical "Swiss," as they were the first to be called, whose union formed the nucleus of the larger unions which, through varied fortunes, eventually grew up. Severally independent as were the cantons composing these larger unions, there at first existed feuds among them, which were suspended during the needs for joint defense. Only gradually did the leagues pass from temporary and unsettled forms to a permanent and settled form. Two facts of significance should be added. One is that, at a later date, a like process of resistance, federation, and emancipation from feudal tyranny, among separate communities occupying small mountain-valleys, took place in the Grisons and in the Valais—regions which, though mountainous, were more accessible than those of the Oberland and its vicinity. The other is that the more level cantons neither so early nor so completely gained their independence; and, further, that their internal constitutions were less free in form. A marked contrast existed between the aristocratic republics of Berne, Lucerne, Fribourg, and Soleure and the pure democracies of the forest cantons and the Grisons; in the last of which

"every little hamlet resting in an Alpine valley, or perched on mountain-crag, was an independent community, of which all the members were absolutely equal—entitled to vote in every assembly, and qualified for every public function. . . . Each hamlet had its own laws, jurisdiction, and privileges," the hamlets being federated into communes, the communes into districts, and the districts into a league.

Lastly, with the case of Switzerland may be associated that of San Marino—a little republic which, seated in the Apennines, and having its center on a cliff a thousand feet high, has retained its independence for fifteen centuries. Here eight thousand people are governed by a senate of sixty, and by captains elected every half year, assemblies of the whole people being called on important occasions. There is a standing army of eighteen, "taxation is reduced to a mere nothing," and officials are paid by the honor of serving.

One noteworthy difference between the compound heads arising under physical conditions of the kinds exemplified, must not be overlooked—the difference between the oligarchic form and the more or less popular form. As shown at the outset of this section, if each of the groups united by militant coöperation is despotically ruled—if the groups are severally framed on the patriarchal type, or are severally governed by men of supposed divine descent—then the compound head becomes one in which the people at large have no share. But if, as in these modern cases, patriarchal authority has decayed; or if belief in divine descent has been undermined by a creed at variance with it; or if peaceful habits have weakened that coercive authority which war ever strengthens—then the compound head is no longer an assembly of petty despots. With the progress of these changes it becomes more and more a head formed of those who exercise power not by right of position but by right of appointment.

There are other conditions which favor the rise of compound heads, temporary if not permanent: those, namely, which occur at the dissolutions of preceding organizations. Among people habituated through countless generations to personal rule, having sentiments appropriate to it, and no conception of anything else, the fall of one despot is at once followed by the rise of another; or, if a large personally-governed empire collapses, its parts severally generate governments for themselves of like kind. But, among less servile peoples, the breaking up of political systems having single heads is apt to be followed by the establishment of others having compound heads; especially where there is a simultaneous separation into parts which have not local governments of stable kinds. Under such circumstances there is a return to the primitive state. The preëxisting regulative system having fallen, the members of the community are left without any controlling power save the aggregate will; and, political organization having to commence afresh, the form first assumed is akin to that

which we see in the assembly of the savage horde, or in the modern public meeting. Whence there presently results the rule of a select few subject to the approval of the many.

In illustration may first be taken the rise of the Italian republics. When, during the ninth and tenth centuries, the German emperors, who had long been losing their power to restrain local antagonisms in Italy and the outrages of wandering robber bands, failed more than ever to protect their subject communities, and, as a simultaneous result, exercised diminished control over them, it became at once necessary and practicable for the Italian towns to develop political organizations of their own. Though in these towns there were remnants of the old Roman organization, this had obviously become effete; for, in time of danger, there was an assembling of "citizens at the sound of a great bell, to concert together the means for their common defense." Doubtless on such occasions were marked out the rudiments of those republican constitutions which afterward arose. Though it is alleged that the German emperors allowed the towns to form these constitutions, yet we may reasonably conclude, rather, that, having no care further than to get their tribute, they made no efforts to prevent the towns from forming them. And though Sismondi says of the towns-people, "ils cherchèrent à se constituer sur le modèle de la république romaine," yet we may question whether, in those dark days, the people knew enough of Roman institutions to be influenced by their knowledge. With more probability may we infer that "this meeting of all the men of the state capable of bearing arms . . . in the great square," originally called to take measures for repelling aggressors—a meeting which must, at the very beginning, have been swayed by a group of dominant citizens, and must have chosen leaders—was itself the republican government in its incipient form. Meetings of this kind, first occurring on occasions of emergency, would gradually come into use for deciding on all important public questions. Repetition would bring greater regularity in the modes of procedure, and greater definiteness in the divisions formed, ending in compound political heads, presided over by elected chiefs. And that this was the case in those early stages of which there remain but vague accounts, is shown by the fact that a similar, though somewhat more definite, process afterward occurred at Florence, when the usurping nobles were overthrown. Definite records tell us that in 1250 "the citizens assembled at the same moment in the square of Santa Croce; they divided themselves into fifty groups, of which each group chose a captain, and thus formed companies of militia: a council of these officers was the first-born authority of this newly revived republic." Clearly that sovereignty of the people which, for a time, characterized these small governments, would inevitably arise if the political form grew out of the original public meeting; while it would be unlikely to have arisen had the political form been artificially devised by a limited class.

That this interpretation harmonizes with the facts which modern times have furnished, scarcely needs pointing out. On an immensely larger scale and in ways variously modified, here by the slow collapse of an old *régime* and there by combination for war, the rise of the first French Republic and that of the American Republic have similarly shown us this tendency toward resumption of the primitive form of political organization, when a decayed or otherwise incapable government is broken up. Greatly obscured by complicating circumstances and special incidents as these transformations were, we may recognize in them the play of the same general causes.

In the last chapter we saw that, as conditions determine, the first element of the triune political structure may be differentiated from the second in various degrees — beginning with the warrior-chief slightly predominant over other warriors, and ending with the divine and absolute king, widely distinguished from the select few next to him. By the foregoing examples we are shown that the second element is, as conditions determine, variously differentiated from the third: being at the one extreme qualitatively distinguished in a high degree and divided from it by an impassable barrier, and at the other extreme almost merged into it.

Here we are introduced to the truth next to be dealt with: that not only do conditions determine the various forms which compound heads assume, but that conditions determine the various changes they undergo. There are two leading kinds of such changes—those through which the compound head passes toward a less popular form, and those through which it passes toward a more popular form. We will glance at them in this order.

Progressive narrowing of the compound head is one of the concomitants of continued military activity. Beginning with the case of Sparta, the constitution of which in its early form differed but little from that which the "Iliad" shows us existed among the Homeric Greeks, we see, in the first place, the tendency toward concentration of power in the regulation, made a century after Lykurgus, that, "in case the people decided crookedly, the senate with the kings should reverse their decisions"; and then we see that later, in consequence of the gravitation of property into fewer hands, "the number of qualified citizens went on continually diminishing": the implication being not only a relatively-increased power of the oligarchy, but, probably, a growing supremacy of the wealthier members within the oligarchy itself. Turning to the case of Rome, ever militant, we find that in course of time inequalities increased to the extent that the senate became "an order of lords, filling up its ranks by hereditary succession, and exercising collegiate misrule"; and then "out of the evil of oligarchy there emerged the still worse evil of usurpation of power by particular families." In the Italian republics, again, perpetually at

war one with another, there resulted a kindred narrowing of the governing body. The nobility, deserting their castles, began to direct "the municipal government of the cities, which consequently, during this period of the republics, fell chiefly into the hands of the superior families." Then at a later stage, when industrial progress had generated wealthy commercial classes, these, competing with the nobles for power, and finally displacing them, repeated within their respective bodies this same process. The richer guilds deprived the poorer of their shares in the choice of the ruling agencies ; the privileged class was continually narrowed by disqualifying regulations ; and newly risen families were excluded by those of long standing. So that, as Sismondi points out, such of the numerous Italian republics as remained nominally such at the close of the fifteenth century were, like "Sienna and Lucca, each governed by a single caste of citizens : . . . had no longer popular governments." A kindred result occurred among the Dutch. During the wars of the Flemish cities with the nobles and with one another, the relatively popular governments of the towns became narrowed. The greater guilds excluded the lesser from the ruling body, and their members "clothed in the municipal purple . . . ruled with the power of an aristocracy ; . . . the local government was often an oligarchy, while the spirit of the burghers was peculiarly democratic." And with these illustrations may be joined that furnished by those Swiss cantons which, physically characterized in ways less favorable to individual independence, were at the same time given to wars, offensive as well as defensive. Berne, Lucerne, Fribourg, Soleure, acquired political constitutions in large measure oligarchic ; and in "Berne, where the nobles had always been in the ascendant, the entire administration had fallen into the hands of a few families, with whom it had become hereditary."

We have next to note as a cause of progressive modification in compound heads, that, like simple heads, they are apt to be subordinated by their administrative agents. The first case to be named is one in which this effect is exemplified along with the last—the case of Sparta. Originally appointed by the kings to perform prescribed duties, the ephors first made the kings subordinate, and eventually subordinated the senate ; so that they became substantially the rulers. From this we may pass to the instance supplied by Venice, where power, once exercised by the people, gradually lapsed into the hands of an executive body, the members of which, habitually reëlected, and at death replaced by their children, became an aristocracy, whence there eventually grew the Council of Ten, who were, like the Spartan ephors, "charged to guard the security of the state with a power higher than the law" ; and who thus, "restrained by no rule," constituted the actual government. Through its many revolutions and changes of constitution, Florence exhibited like tendencies. The appointed administrators, now signoria, now priors, became able, during

their terms of office, to carry out their ends even to the extent of suspending the constitution—getting the forced assent of the assembled people, who were surrounded by armed men. And then, eventually, the head executive agent, nominally reëlected from time to time but practically permanent, became, in the person of Cosmo de' Medici, the founder of an inherited headship.

But the liability of the compound political head to become subject to its civil agents, is far less than its liability to become subject to its military agents. From the earliest times this liability has been exemplified and commented upon; and, familiar as it is, I must here illustrate and emphasize it, because it directly bears on one of the cardinal truths of political theory. Setting out with the Greeks we observe, in the first place, that the tyrants, by whom oligarchies were so often overthrown, had armed forces at their disposal. Either the tyrant was "the executive magistrate, upon whom the oligarchy themselves had devolved important administrative powers," or he was a demagogue, who pleaded the alleged interests of the community, "in order to surround" himself "with armed defenders"—soldiers being in either case the agents of his usurpation. And then, in the second place, we see the like done by the successful general. As Macchiavelli remarks of the Romans: "For the further abroad they [the generals] carried their arms, the more necessary such prolongations [of their commissions] appeared, and the more common they became; hence it arose, in the first place, that but a few of their citizens could be employed in the command of armies, and consequently few were capable of acquiring any considerable degree of experience or reputation; and in the next, that when a commander in chief was continued for a long time in that post, he had an opportunity of corrupting his army to such a degree that the soldiers entirely threw off their obedience to the senate, and acknowledged no authority but his. To this it was owing that Sylla and Marius found means to debauch their armies and make them fight against their country; and that Julius Cæsar was enabled to make himself absolute in Rome."

The Italian republics, again, furnish many illustrations. By the beginning of the fourteenth century, those of Lombardy "all submitted themselves to the military power of some nobles to whom they had intrusted the command of their militias, and thus all lost their liberty." Later times and nearer regions yield instances. At home Cromwell showed how the successful general tends to become autocrat. In the Netherlands the same thing was exemplified by the Van Arteveldes, father and son, and again by Maurice of Nassau; and, but for form's sake, it would be needless to name the case of Napoleon. It should be added that not only by command of armed forces is the military chief enabled to seize on supreme power, but acquired popularity, especially in a militant nation, places him in a position which makes it relatively easy to do this. Neither their own experience, nor

the experiences of other nations throughout the past, prevented the French from lately making Marshal MacMahon executive head; and even the Americans, in more than once choosing General Grant for President, proved that, predominantly industrial though their society is, militant activity promptly caused an incipient change toward the militant type, of which an essential trait is the union of civil headship with military headship.

From the influences which tend to narrow compound political headships, or change them into single ones, let us pass to the influences which tend to widen them. The case of Athens is, of course, the first to be considered. To understand this we must remember that, up to the time of Solon, democratic government did not exist in Greece. The only known forms were the oligarchic and the despotic; and in those early days, before political speculation began, it is certain that there was not recognized in theory a social form wholly unknown in practice. We have, therefore, to exclude the notion that popular government arose in Athens under the guidance of any preconceived idea. As having the same implication should be added the fact that—Athens being governed by an oligarchy at the time—the Solonian legislation served but to qualify and broaden the oligarchy and remove crying injustices. In seeking the causes which worked through Solon, and also made practicable the reorganization he initiated, we shall find them to lie in the direct and indirect influences of trade. Grote comments on "the anxiety, both of Solon and of Drako, to enforce among their fellow-citizens industrious and self-maintaining habits"—a proof that, even before Solon's time, there was in Attica little or no reprobation of "sedentary industry, which in most other parts of Greece was regarded as comparatively dishonorable." Moreover, Solon was himself in early life a trader; and his legislation "provided for traders and artisans a new home at Athens, giving the first encouragement to that numerous town-population, both in the city and in the Peiræus, which we find actually residing there in the succeeding century." The immigrants who flocked into Attica because of its greater security, Solon was anxious to turn rather to manufacturing industry than to cultivation of a soil naturally poor; and one result was "a departure from the primitive temper of Atticism, which tended both to cantonal residence and rural occupation"; while another result was to increase the number of people who stood outside those gentile and phratric divisions, which were concomitants of the patriarchal type and of personal rule. And then the constitutional changes made by Solon were in leading respects toward industrial organization. The introduction of a property-qualification for classes, instead of a birth-qualification, diminished the rigidity of the political form, since acquirement of wealth by industry, or otherwise, made possible an admission into the oligarchy, or among others of the privileged. By forbidding self-enslavement of the debtor, and by emancipating those who had been

self-enslaved, his laws added largely to the enfranchised class as distinguished from the slave-class. In another aspect this change, leaving equitable contracts untouched, prevented those inequitable contracts under which, by a lien on himself, a man gave more than an equivalent for the sum he borrowed. And, with a decreasing number of cases in which there existed the relation of master and slave, went an increasing number of cases in which benefits were exchanged by agreement. The odium attaching to that lending at interest which ended in slavery of the debtor having disappeared, legitimate lending became general and unopposed, the rate of interest was free, and accumulated capital was made available. Then, as coöperating cause, and as ever-increasing consequence, came the growth of a population favorably circumstanced for acting in concert. Urban people, who, daily in contact, can gather one another's ideas and feelings, and who, by quickly-diffused intelligence, can be rapidly assembled, can coöperate far more readily than those who are scattered through rural districts. With all which direct and indirect results of industrial development must be joined the ultimate result upon character, produced by daily fulfilling and enforcing contracts—a discipline which, while requiring each man to recognize the claims of others, also requires him to maintain his own. In Solon himself this attitude which joins assertion of personal rights with respect for the rights of others was well exemplified; since, when his influence was great he refused to become a despot, though pressed to do so, and in his latter days he resisted at the risk of death the establishment of a despotism. In various ways, then, increasing industrial activity tended to widen the original oligarchic form, and initiate a more popular form. And though these effects of industrialism, joined with subsequently-accumulated effects, were for a long time held in check by the usurping Peisistratidæ, yet, being ready to show themselves when, some time after the expulsion of these tyrants, there came the Kleisthenian revolution, they were doubtless instrumental in then initiating the popular form of government.

Though not in so great a degree, yet in some degree, the same causes operated in liberalizing and widening the Roman oligarchy. Rome "was indebted for the commencement of its importance to international commerce"; and, as Mommsen points out, "the distinction between Rome and the mass of the other Latin towns must certainly be traced back to its commercial position, and to the type of character produced by that position. . . . Rome was the emporium of the Latin districts." Moreover, as in Athens, though doubtless to a smaller extent, trade brought an increasing settlement of strangers, to whom rights were given, and who, joined with emancipated slaves and with clients, less bound to their patrons, formed an industrial population, the eventual inclusion of which in the burgess-body caused that widening of the constitution effected by Servius Tullius.

The Italian republics of later days again show us, in numerous

cases, this connection between trading activities and a freer form of rule. The Italian towns were industrial centers. "The merchants of Genoa, Pisa, Florence, and Venice supplied Europe with the products of the Mediterranean and of the East; the bankers of Lombardy instructed the world in the mysteries of finance and foreign exchanges; Italian artificers taught the workmen of other countries the highest skill in the manufactures of steel, iron, bronze, silk, glass, porcelain, and jewelry. Italian shops, with their dazzling array of luxuries, excited the admiration and envy of foreigners from less favored lands." Then, on looking into their histories, we find that industrial guilds were the bases of their political organizations; that the upper mercantile classes became the rulers, in some cases excluding the nobles; and that, while external wars and internal feuds tended continually to revive narrower, or more personal, forms of rule, rebellions of the industrial citizens, from time to time occurring, tended to reëstablish popular rule.

When we join with these the like general connections that arose in the Netherlands and in the Hanse towns; when we remember the liberalization of our own political institutions which has gone along with growing industrialism; when we observe that the towns more than the country, and the great industrial centers more than the small ones, have given the impulses to these changes—it becomes unquestionable that, while by increase of militant activities compound headships are narrowed, they are widened in proportion as industrial activities become predominant.

In common with the results reached in preceding chapters, the results above reached show that types of political organization are not matters of deliberate choice. It is common to speak of a society as though it had, once upon a time, decided on the form of government which thereafter existed in it. Even Mr. Grote, in his comparison between the institutions of ancient Greece and those of mediæval Europe (vol. iii, pages 10–12) tacitly implies that conceptions of the advantages or disadvantages of this or that arrangement furnished motives for establishing or maintaining it. But, as gathered together in the foregoing sections, the facts show us that, as with the genesis of simple political headships, so with the genesis of compound political headships, conditions and not intentions determine.

Recognizing the fact that independence of character is a factor, but ascribing this independence of character to the continued existence of a race in a habitat which facilitates evasion of control, we saw that, with such a nature so conditioned, coöperation in war causes the union on equal terms of groups whose heads are joined to form a directive council. And according as the component groups are governed more or less autocratically, the directive council is more or less oligarchic. We have seen that in localities differing so widely as do moun-

tain-regions, marshes or mud-islands, and jungles, men of different races have developed political heads of this compound kind. And, on observing that the localities, otherwise so unlike, are alike as being severally made up of parts difficult of access, we can not question that to this is mainly due the governmental form under which their inhabitants unite.

Besides the compound headships which are thus indigenous in places favoring them, there are other compound headships which arise after the break-up of preceding political organizations. Especially apt are they so to arise where the people, not scattered through a wide district but concentrated in a town, can assemble bodily. Control of every kind having disappeared, it happens in such cases that the aggregate will has free play, and there establishes itself for a time that relatively popular form with which all government begins; but, regularly or irregularly, a superior few become differentiated from the many, and of predominant men some one is made, directly or indirectly, most predominant.

Compound headships habitually become, in course of time, either narrower or wider. They are narrowed by militancy, which tends ever to concentrate directive power in fewer hands, and, if continued, almost certainly changes them into simple headships. Conversely, they are widened by industrialism. This, by gathering together aliens detached from the restraints imposed by patriarchal, feudal, or other such organizations, by increasing the number of those to be coerced in comparison with the number of those who have to coerce them, by placing this larger number in conditions favoring concerted action, by substituting for daily enforced obedience the daily fulfillment of voluntary obligations and daily maintenance of claims, tends ever toward equalization of citizenship.

DEGENERATION.

By Dr. ANDREW WILSON.

IT can not be gainsaid that a survey of the fields of life around us impresses one with the idea that the general tendencies of living nature gravitate toward progression and improvement, and are modeled on lines which, as Von Baer long ago remarked, lead from the general or simple toward the definite special and complex. This much is admitted on all hands, and the ordinary courses of life substantiate the aphorism that progress from low grades and humble ways is the law of the organic universe that hems us in on every side, and of which, indeed, we ourselves form part. The growth of plant-life, which runs concurrently with the changing seasons of the year, impresses this

fact upon us, and the history of animal development but repeats the tale. From seed to seed-leaf, from seed-leaf to stem and leaves, from simple leaves to flower, and from flower to fruit, there is exhibited a natural progress in plant-existence, which testifies eloquently enough, by analogy at least, to the existence of like tendencies in all other forms of life. Similarly, in the animal host, progressive change is seen to convert that which is literally at first "without form and void" into the definite structure of the organism. A minute speck of protoplasm on the surface of the egg—a speck that is indistinguishable, in so far as its matter is concerned, from the *materies* of the animalcule of the pool—is the germ of the bird of the future. Day by day the forces and powers of development weave the protoplasm into cells, and the cells into bone and muscle, sinew and nerve, heart and brain. In due season the form of the higher vertebrate is evolved, and progressive change is once more illustrated before the waiting eyes of life-science. But the full meaning of most problems which life-science presents to view is hardly gained by a merely cursory inspection of what may be called the normal side of things. The by-paths of development—more frequently, perhaps, than its beaten tracks—reveal guiding clews and traces of the manner in which the progress in question has come to pass. So, also, the side-avenues of biology open up new phases of, it may be, the main question at issue, and may reveal, as in the present instance, an interesting reverse to the aspects we at first deem of sole and paramount importance. For example, a casual study of the facts of animal development is well calculated to show that life is not all progress, and that it includes retrogression as well as advance. Physiological history can readily be proved to tend in many cases toward backsliding, instead of reaching forward and upward to higher levels. This latter tendency, beginning now to be better recognized in biology than of late years, can readily be shown to exercise no unimportant influence on the fortunes of animals and plants. In truth, life at large must now be regarded as existing between two great tendencies—the one progressive and advancing, the other retrogressive and degenerating. Such a view of matters may serve to explain many things in living histories which have hitherto been regarded as somewhat occult and difficult of solution; while we may likewise discover that the coexistence of progress and retrogression is a fact perfectly compatible with the lucid opinions and teachings concerning the origin of living things which we owe to the genius of Darwin and his disciples.

A fundamental axiom of modern biology declares that in the development of a living being we may discern a panoramic unfolding, more or less complete, of its descent. "Development repeats descent" is an aphorism which cultured biology has everywhere writ large over its portals. Rejecting this view of what development teaches, the phases through which animals and plants pass in the course of their

progress from the germ to the adult stage present themselves to view as simply meaningless facts and useless freaks and vagaries of Nature. Accepting the idea—favored, one may add, by every circumstance of life-science—much that was before wholly inexplicable becomes plain and readily understood. And the view that a living being's development is really a quick and often abbreviated summary of its evolution and descent both receives support from and gives countenance to the general conclusion that life's forces tend as a rule toward progress, but likewise exhibit retrogression and degeneration. If a living being is found to begin its history, as all animals and plants commence their existence, as a speck of living jelly, comparable to the animalcule of the pool, it is a fair and logical inference that the organisms in question have descended from lowly beings, whose simplicity of structure is repeated in the primitive nature of the germ. If, to quote another illustration, the placid frog of to-day, after passing through its merely protoplasmic stage, appears before us in the likeness of a gill-breathing fish (Fig. 1), the assumption is plain and warrantable that the frog

Fig. 1.—Development of Frog.

race has descended from some primitive fish stock, whose likeness is reproduced with greater or less exactness in the tadpoles of the ditches. Or if, to cite yet another example, man and his neighbor quadrupeds (Fig. 2), birds, and reptiles, which never breathe by gills at any period of their existence, are found in an early stage of development to possess "gill-arches" (*g*), such as we naturally expect to see, and such as we find in the fishes themselves, the deduction that these higher animals are descended from gill-bearing or aquatic ancestors admits of

no denial. On any other theory, the existence of gill-arches in the young of an animal which never possesses gills is to be viewed as an inexplicable freak of Nature—a dictum which, it is needless to remark, belongs to an era one might well term prescientific, in comparison with the "sweetness and light" of these latter days.

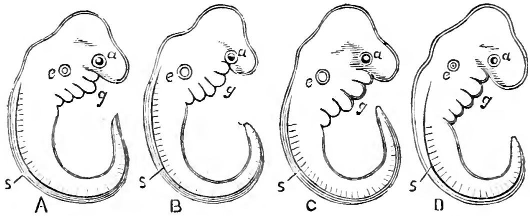


FIG. 2.—PIG. CALF. RABBIT. MAN.

Hanging very closely on the aphorism respecting development and its meaning, is another biological axiom, wellnigh as important as the former. If development teaches that life has been and still is progressive in its ways, and that the simpler stages in an animal's history represent the conditions of its earliest ancestors, it is a no less stable proposition that at all stages of their growth living beings are subject to the action of outward and inward forces. Every living organism lives under the sway and dominance of forces acting upon it from without, and which it is enabled to modify and to utilize by its own inherent capabilities of action. It is, in fact, the old problem of the living being and its surroundings applied to the newer conceptions of life and nature which modern biology has revealed. The living thing is not a stable unit in its universe, however wide or narrow that sphere may be. On the contrary, it exists in a condition of continual war, if one may so put it, between its own innate powers of life and action, of living and being, and the physical powers and conditions outside. This much is now accepted by all scientists. Differences of opinion certainly exist as to the share which the internal constitution of the living being plays in the drama of life and progress. It seems, however, most reasonable to conclude that two parties exist to this, as to every other bargain; and, regarding the animal or plant as plastic in its nature, we may assume such plasticity to be modified on the one hand by outside forces, and on the other by internal actions proper to the organism as a living thing. Examples of such tendencies of life are freely scattered everywhere in Nature's domain. For instance, we know of many organisms which have continued from the remotest ages to the present time, without manifest change of form or life, and which appear before us to-day the living counterparts of their fossilized representatives of the chalk, or it may be of Silurian or Cambrian times. The lamp-shells (*Terebratula*) of the chalk exist in our own seas with wellnigh inappreciable differences. The *Lingula*

or *Lingulella* (Fig. 3, *a*), another genus of these animals, has persisted from the Cambrian age (*b*, *c*) to our own times, presenting little or no change for the attention of the geological chronicler. The curious king-crabs, or *Limuli* (Fig. 4), of the West Indies are likewise pre-

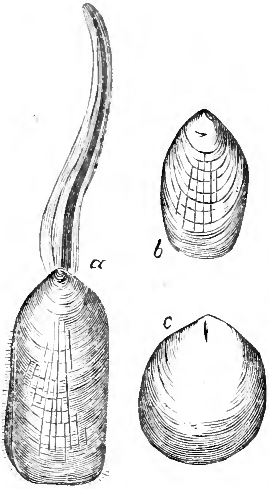


FIG. 3.—LINGULA.

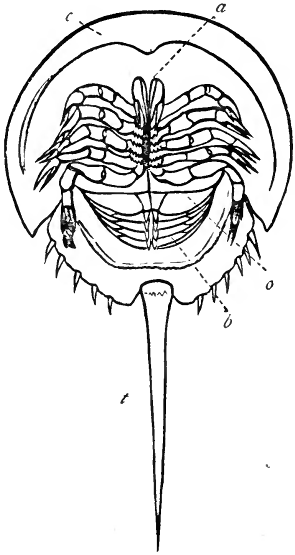


FIG. 4.—KING CRAB.

sented to our view, with little or no variation, from very early ages of cosmical history; and of the pearly nautilus (Fig. 8)—now remaining as the only existing four-gilled and externally shelled cuttle-fish—the same remark holds good. The fishes, likewise, are not without their parallel instances of lack of change and alteration throughout long ages of time. The well-known case of the genus *Beryx* presents us with a fish of high organization, found living in the Atlantic and Pacific Oceans, and which possesses fossil representatives and *fac-similes* in the chalk (Fig. 5.) From the latter period to the present day, the genus *Beryx* has therefore undergone little modification or change. The same remark certainly holds good of many of those huge "dragons of the prime" (Figs. 6 and 7), which reveled in the seas of the Trias, Oölite, and Chalk epochs—developed in immense numbers in these eras of earth's history, but disappearing for ever from the lists of living

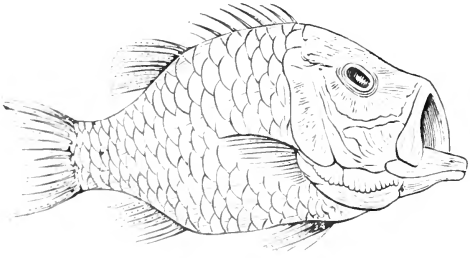


FIG. 5.—BERYX.

things at the close of the Cretaceous age, and exhibiting little or no change during their relatively brief history.

Such cases of stability amid conditions which might well have favored change, and which saw copious modification and progression in other groups of animals, might at first sight be regarded as presenting a serious obstacle to the doctrine of progressive development on which the whole theory of evolution depends. As such an obstacle, the series of facts in question was long regarded ; as such, these facts are sometimes even now advanced, but only by those who imperfectly appreciate and only partially understand what the doctrine of evolution teaches and what its leading idea includes. Even Cuvier himself, when advancing the case of the apparently unchanged mummies of Egyptian animals against Lamarck's doctrine of descent, failed—possibly through the imperfectly discussed stage in which the whole question rested in his day—to understand that the very facts of preservation revealed in the monuments of Egypt testified to the absence of those physical changes which could alone have affected the animals of the Nile land. But the fuller consideration of that theory of nature which credits progressive change as the usual way of life, shows us that it is no part of evolution to maintain either that living beings must needs undergo continual change, or that they must change and modify at the same rate. On the contrary, Mr. Darwin, in his classic work, maintains exactly the opposite proposition. There are, in fact, two great factors at work in living nature—a tendency to vary and change, and the influence of environments or surroundings. Given the first tendency, which is not at all a matter of dispute, the influence of the second is plainly enough discernible in bringing to the front either the original,

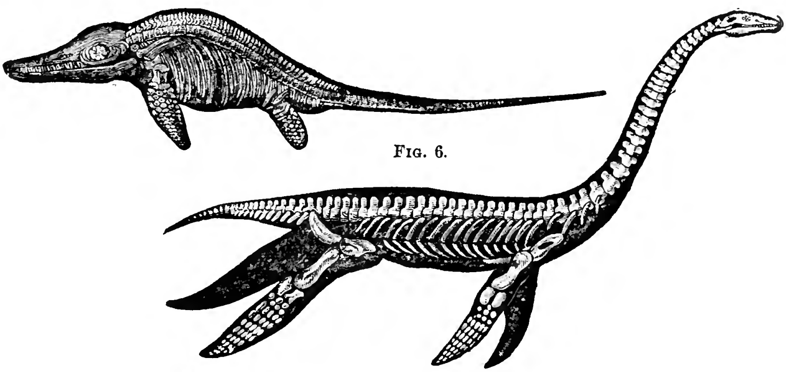


FIG. 6.

FIGS. 6 AND 7.—ICHTHYOSAURUS AND PLESIOSAURUS.

primitive, or, as it might be named, the parent form, or the varying forms which are produced by modification of the parent. As it has well been put : "Granting the existence of the tendency to the production of variations, then, whether the variations which are produced

shall survive and supplant the parent, or whether the parent form shall survive and supplant the variations, is a matter which depends entirely on those conditions which give rise to the struggle for existence. If the surrounding conditions are such that the parent form is more competent to deal with them and flourish in them than the derived forms, then in the struggle for existence the parent form will maintain itself, and the derived forms will be exterminated. But, if, on the contrary, the conditions are such as to be more favorable to a derived than to the parent form, the parent form will be extirpated, and the derived form will take its place. In the first case, there will be no progression, no change of structure, through any imaginable series of ages; in the second place, there will be modification and change of form." To the same end Darwin himself leads us. In one or two very pregnant passages, the author of the "Theory of Natural Selection" very plainly indicates why progression should not be universal, and why certain beings remain lowly organized while others attain to the summit and pinnacle of their respective organizations. "How is it," says Darwin, "that throughout the world a multitude of the lowest forms still exist? and how is it that in each great class some forms are far more highly developed than others? Why have not the more highly developed forms everywhere supplanted and exterminated the lower?" Answering his own queries, Darwin says that natural selection by no

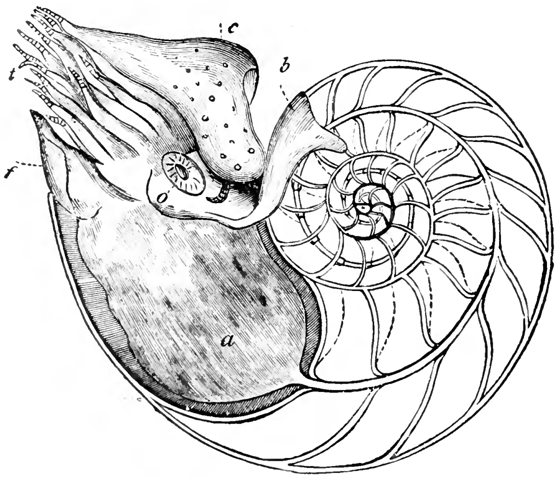


Fig. 8.—Pearly Nautilus.

means includes "progressive development—it only takes advantage," he remarks, "of such variations as arise and are beneficial to each creature under its complex relations of life. And it may be asked, what advantage, as far as we can see, would it be to an infusorian animalcule—to an intestinal worm—or even to an earthworm, to be highly organized? If it were no advantage, these forms would be

left, by natural selection, unimproved or but little improved, and might remain for ages in their present lowly condition. And geology tells us that some of the lowest forms, as the foraminifera (Fig. 9), infusoria, and rhizopods, have remained for an enormous period in nearly their present state. But," adds Darwin, with a characteristically impartial view of matters, "to suppose that most of the many now existing low forms have not in the least advanced since the first dawn of life would be extremely rash ; for every naturalist who has dissected some of the beings now ranked as very low in the scale must have been struck with their really wondrous and beautiful organization."

Thus one of the plainest facts of natural history, namely, that in even one group or class of animals we find forms of exceedingly low structure included along with animals of high organization — the apparently diverse bodies being really modeled on the one and the same type—is explained by the consideration that with different conditions, or with various conditions acting differently upon unlike constitutions, we expect to find extreme differences in the rank to which the members of a class may attain. In the class of fishes we find the worm-like, clear-bodied lancelet of an inch long associated with the ferocious shark, the active dogfish, or the agile food-fishes of our table. But, as Darwin remarks, the shark would not tend to supplant the lancelet, their spheres and their conditions of existence being of diverse nature. The same remark applies to many other classes of living beings. So that lowly beings still live as such among us, and preserve the primitive simplicity of their race, firstly, because the conditions of life and their limited numbers may not have induced any great competition or struggle for existence. On the "let-well-alone" principle we may understand why some animals, such as the lancelet itself, have lagged behind in the race after progress. Then, secondly, as Darwin remarks, favorable variations, by way of beginning the work of progress, may never have appeared—a result due, probably, as much to hidden causes within the living being as to outside conditions. We may not fail to note, lastly, that the simpler and more uniform these latter conditions are—as represented in the abysses of the ocean, for example—the less

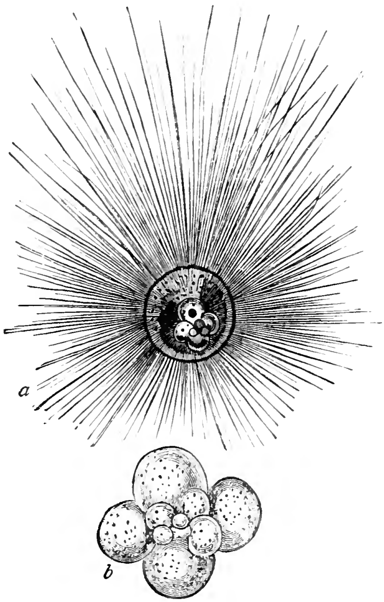


Fig. 9.—Globigerina, etc.

incentive is there for the progress and evolution of the races which dwell in their midst.

This somewhat lengthy introduction to the subject of degeneration and its results is in its way necessary for the full appreciation of the fashion in which degeneration relates itself to the other conditions of life. From the preceding reflections it becomes clear that three possibilities of life await each living being. Either it remains primitive and unchanged, or it progresses toward a higher type, or, last of all, it backslides and retrogresses. As the first condition, that of stability, is, as already noted, perfectly consistent with the doctrine of descent, so are the two latter conditions part and parcel of that theory. The stable state forces the animal to remain as it now is, or as it has been in all times past; the progressive tendency will make it a more elaborate animal: and the progress of degeneration will, on the other hand, tend to simplify its structure. It requires no thought to perceive that progress is a great fact of nature. The development of every animal and plant shows the possibilities of nature in this direction. But the bearings of degeneration and physiological backsliding are not, perchance, so clearly seen; hence, to this latter aspect of biology we may now specially direct our attention.

That certain animals degenerate or retrogress in their development before our eyes to-day, is a statement susceptible of ready and familiar illustration. No better illustrations of this statement can be found than those derived from the domain of parasitic existence. When an animal or plant attaches itself partly or wholly to another living being, and becomes more or less dependent upon the latter for support and nourishment, it exhibits, as a rule, retrogression and degeneration. The parasitic "guest" dependent on its "host" for lodging alone, or it may be for both board and lodging, is in a fair way to become degraded in structure, and, as a rule, exhibits degradation of a marked kind, where the association has persisted sufficiently long. Parasitism and servile dependence act very much in structural lower life as analogous instances of mental dependence on others act in ourselves. The destruction of characteristic individuality and the extinction of personality are natural results of that form of association wherein one form becomes absolutely dependent on another for all the conditions of life. A life of attachment exhibits similar results, and organs of movement disappear by the law of disuse. A digestive system is a superfluity

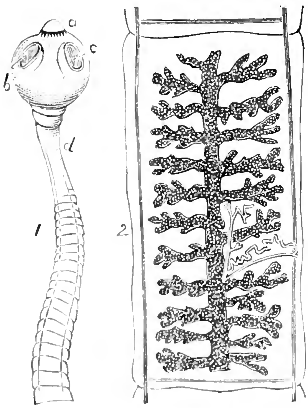


FIG. 10.—COMMON TAPEWORM (*Tænia solium*). 1. The head extremity, magnified, showing hooks (*a*), and suckers (*b*, *c*); *d*, neck, with immature joints. 2. A joint, largely magnified, showing the branching "ovary," in which the numerous eggs of each joint are matured.

to an animal which, like a tapeworm (Fig. 10), obtains its food ready-made in the very kitchen, so to speak, of its host. Hence the lack of a digestive apparatus follows the finding of a free commissariat by the parasite. Organs of sense are not necessary for an attached and rooted animal; these latter, therefore, go by the board, and the nervous system itself becomes modified and altered. Degradation, wholesale and complete, is the penalty the parasite has to pay for its free board and lodging; and in this fashion Nature may be said to revenge the host for the pains and troubles wherewith, like the just of old, he may be tormented. Numerous life-histories testify clearly enough to the correctness of the foregoing observations. Take, as an example, the history of *Sacculina* (Fig. 11, A), which exists as a bag-like growth attached to the bodies of hermit-crabs, and sends root-like processes into the liver of its host. No sign of life exists in a

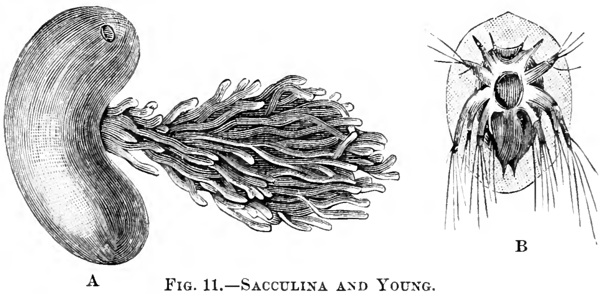


FIG. 11.—SACCULINA AND YOUNG.

sacculina beyond mere pulsation of the sac-like body, into and from which water flows by an aperture. Lay open this sac, and we shall find the animal to be a bag of eggs and nothing more. But trace the development of a single egg, and one may derive therefrom lessons concerning living beings at large, and open out issues which spread and extend far afield from sacculina and its kin. Each egg of the sac-like organism develops into a little active creature, possessing three pairs of legs, generally a single eye, but exhibiting no mouth or digestive system—parasitism having affected the larva as well as the adult. Sooner or later, this larva—known as the *nauplius* (B)—will develop a kind of bivalve shell; the two hinder pairs of limbs are cast off and replaced by six pairs of short swimming-feet; while the front pair of limbs develops to form two elongated organs whereby the young sacculina will shortly attach itself to a crab "host." When the latter event happens, the six pairs of swimming-feet are cast off, the body assumes its sac-like appearance, and the sacculina sinks into its adult stage—a pure example of degradation by habit, use, and wont. So also with certain near neighbors of these crab-parasites, such as the *Lerneans*, which adhere to the gills of fishes. Beginning life as a three-legged "nauplius," the lernean retrogresses and de-

generates to become a mere elongated worm, devoted to the production of eggs, and exhibiting but little advance on the sacculina. There are dozens of low crustaceans which, like sacculina, afford examples of animals which are free and locomotive in the days of their youth, but which, losing eyes, legs, digestive system, and all the ordinary belongings of animal life, "go to the bad," as a natural result of participating in what has been well named "the vicious cycle of parasitism."

Plainly marked as are the foregoing cases, there are yet other familiar crustaceans which, although not parasites, as a rule, nevertheless illustrate animal retrogression in an excellent manner. Such are the sea-acorns (*Balani*), which stud the rocks by thousands at low-water mark, and such are the barnacles (Fig. 12), that adhere to floating timber and the sides of ships. In the development of sea-acorns and barnacles, the first stage is essentially like that of the sacculina. The young barnacle is a "nauplius," three-legged, free-swimming, single-eyed, and possessing a mouth and digestive apparatus. In the next stage we again meet with the six pairs of swimming-feet seen in sacculina, with the enormously developed front pair of legs serving as "feelers," and with two "magnificent compound eyes," as Darwin describes the organs of vision. The mouth in this second stage, however, is closed, and feeding is therefore impossible. As Darwin remarks, the function of the young barnacles "at this stage is to search out by their well-developed organs of sense and to reach by their active powers of swimming a proper place on which to become attached, and to undergo their final metamorphosis. When this is completed," adds Darwin, "they are fixed for life; their legs are now converted into prehensile organs; they again obtain a well-constructed mouth, but they have no antennæ, and their two eyes are now reconverted into a minute, single, simple eye-spot." A barnacle is thus simply a highly modified crab-like animal which fixes itself by its head to the floating log, and which "kicks its food into its mouth with its feet," to use the simile and description of biological authority. The development of its "shell" and stalk are matters which do not in the least concern its place in the animal series. These latter are local and personal features of the barnacle tribe. For in the "sea-acorns,"

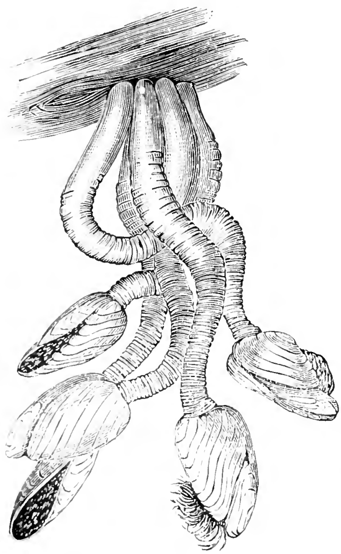


Fig. 12.—Barnacles.

which pass through an essentially similar development, there is no stalk ; and the animal, after its free-swimming stage, simply glues its head, by a kind of marine cement of its own manufacture, to the rock, develops its conical shell, and like the barnacle uses its modified feet as means for exercising the commissariat and nutritive function. It is true that in some respects the adult barnacle may be regarded as lower than the young, and therefore as a degenerate being. Thus, it is lower when eyes, feelers, and movements are taken into account. In other respects the adult may be considered of higher organization than the larva. These higher traits we may logically enough suppose represent the special advances which adult barnacle-life has made on its own account. But, on the whole, degradation and retrogression, if not so fully exemplified as in the sacculina, is still plainly enough illustrated in barnacle history. When we further reflect that even such high crustaceans as prawns and allied forms begin life each as a "nauplius" or under an allied guise, we not only merely discover the common origin of all crustaceans in some form represented by the "nauplius" of to-day, but we also witness the possibilities of development which have placed shrimps, prawns, etc., in the foremost rank of the class, and which, conversely, have left the barnacles and sacculinas, through the action of degenerative changes, among the groundlings of the group.

The assumption of a sedentary life, whether parasitic in nature like that of sacculina, or whether it is represented by mere attachment and fixation to some inorganic thing, as in the case of the barnacles, is therefore seen to operate in the direction of producing degeneration of the animal's constitution. The tendency of such habit is toward simplification of structure and not toward that progressive advance and evolution which, in the case of the higher crustacean races, have evolved from the relatively simple "nauplius" of the past the crabs, lobsters, shrimps, and prawns of to-day.—*Gentleman's Magazine.*

[*To be continued.*]

THE PRIMEVAL AMERICAN CONTINENT.

By L. P. GRATACAP, A.M.

THE reader may recall standing, when a child, by the side of a toy-dam in the course of some little stream, and, were a breach made in the mimic masonry, remember the mute interest with which he watched the slow emergence of fairy islands as points of rock and shoals of mud slowly appeared above the water's surface—how the detached summits, at first round spots, assumed varied outlines indented with cones or bristling with promontories ; how they multiplied as the ebbing water exposed newer and lower levels, until the

tiny sea was dotted with an archipelago of islands, whose nearing shores, gradually joining, formed chains of islets; how the inclosed area of water contracted, and, in the union of all their separate figures, vanished. The wet surfaces, broken by depressions, were marked by pits of water from whose sides stole along intermediate creases, thread-like lines of water, the river system of the miniature continent, its sinuous shores impressed by the ripples of a mimic sea. The recollection of boyish pleasures becomes touched with a deeper interest when one is taught to recognize in this the picture of what in a larger way, and under cosmic conditions, has happened in the life-history of our own sphere, and to realize that his childish hand may have reproduced at will a somewhat exact copy of the stages of the world's growth.

Suppose this little world so briefly made had been left till the bright sunshine had dried its surface, in some places parched and cracked it, in others evoked a luxuriant growth of grass and flowers, filled its shores with gliding snails and its level mead with teeming ant-hills. Once more the running stream is stopped, and slowly the muddy tide rises higher and higher, obliterates the lowlands and creeps slowly up the sides of the high ground, around the skirts of its pygmy mountain-chains, and rolls restored amid groups of remade islets. Under the guidance of this retrospective knowledge let the current be arrested to permit some portions of that first-made land to remain uncovered. With favorable conditions, as a stream carrying abundance of fine silt, the water moving sluggishly over the inundated surfaces will drop its earthy burden upon them in thin, loose layers, evenly at first, but, as shallows are formed, irregularly modified, or as sudden freshets produce stronger currents, eddies and ripple-bars gather or disturb the sediment. New lands in wet banks and knobs will begin to appear over the highest ridges. Break away again the barrier, and cause the water to recede, exposing in a similar succession of phases the bared surface. The expectant eye now notices certain changes: old landmarks are removed from sight, valleys have been converted into plains, new hills have arisen, lakes are seen here and there where before was dry land, new contour lines surround the structural ridges which yet remain, modified indeed, but distinctly recognizable, while the low verdure of grass and the numerous pinnacles of ant-hills have together disappeared beneath a universal blanket of mud. Only upon the very highest points do the scattered remnants of the first surface appear unchanged, because they alone were exempted from general flood. Again the sun shines upon it, new seeds sprout, other insects flourish, and fresh showers fall. In spots the old land is exposed; the new having been washed away from it; it may be easily recognized by its fauna and flora, the drowned ants, and the hidden grass.

Again and again, under varying conditions, may our experimental

world be sunk and raised, preserving, possibly, through all the changes the rudimentary outlines of hills and valleys by which it was first characterized and marked. And imagining that every new stratum was ingeniously varied in the color and to some extent in the nature of its mineral constituents, and that, upon each reappearance of this diminutive continent, the skillful experimentalist spread a new form of life, what at last might be, after some exposure to weathering and change, the character of its surface? Evidently something like this: in the first place, since, in consequence partly of denudation and partly of only partial submergence, certain tracts will appear cleared of the later deposits, we will find numbers of the whole series laid bare in spots from the highest point, where, as presupposed, only the primitive layer is seen, to the outskirts of the island where the latest layer forms the surface; or to interior depressions, where lake-like centers existed alternately filled and emptied with each recurring deluge. Endless diversity might be introduced into such a scheme, so far as local detail is concerned, but under the conditions given the island would exhibit lines of stratification, each distinguished by color or *fossils*, and following each other in the order instituted by the youthful world-makers. Along the crevices and tiny gullies we might detect the minute succession of various strata, and at intervals fragments of the buried life would be revealed. Enlarge this minute illustration till it assumes continental dimensions, reverse the periodic inundations from the water rising to periodic inundations from the land sinking, and in a rude way, subject to important modifications, the reader will be prepared to realize the formative system developed in the construction of our northern hemisphere.

Through a sequence of phases, somewhat distinctively bounded by periods of depression and consequent submergence, and periods of elevation and consequent drainage, land was added to an initial nucleus by enormous marine accumulations, the *débris* of animal organisms, and the detritus from terrestrial abrasion. Chemical action, heat, and molecular transference hardened these layers into stone, and thus the new-made land, though undergoing change from recurring submergence, and through subaërial denudation, yet, to a great extent, resisted removal while it contributed to the growth of the incipient continent, and formed the ground upon which new-laid strata were heaped.

In the American Museum of Natural History, seven maps, the work of Professor R. P. Whitfield, have recently been added to the Geological Cabinet, intended to exhibit the growth of the eastern half of the North American Continent from 95° west longitude eastward to its shores. The scheme of their arrangement is the exhibition, by contrasted colors, of the superficial areas where to-day the rocks of the various geological epochs are exposed, beginning with the oldest and rising to the youngest, whereby we seem to seize at critical points the

stages of the continent's enlargement, and follow with the eye the stupendous changes which shaped it.

The first chart presents in its colored parts the primeval territory, which geologists regard as the first-made land of our continent, the archaic regions, around whose rocky framework were gathered the accretions of succeeding ages. It is the azoic *terrain*, that composite foundation of gneiss, granite, schists, crystalline limestones, sandstones, serpentine, and iron-ore masses, which defined the geological architecture of America. In its isolated ridges, cleared of the later and adjacent strata, we have before our eyes the principal portions of a continent upon which the ancient oceans played

> ". . . their priest-like task
> "Of pure ablution round earth's *lifeless* shores."

Its sterile stretches unalleviated by a mantle of waving woods, unanimated by moving figures, reflected the harsh sunshine from rugged terraces or monotonous lowlands, a cheerless waste bathed by preadamite seas.

Starting from a point near Montgomery, in Alabama, the archæan country stretches northeasterly along the Appalachian axis and, rapidly widening, incloses large districts in Georgia, western South and North Carolina, of which latter State it defines the western boundary, and reaches eastward nearly to Raleigh. Passing on both sides of a lenticular area lying in North Carolina and Virginia, it narrows to a strip west of Richmond, where it is deeply bitten by a round gulf, and pressed to the seaboard, forms a thin isthmus west of Washington, then expands at Baltimore, and, lobed out into a pennant-shaped appendage, reaches down toward Newcastle, Delaware. From a little west of Burlington, nearly to Easton, a white patch shows an area where the archean rock is no longer seen, but at the latter point a thin strip follows the Appalachian uplift and, including the highlands of West Point, appears as an attenuated finger or arm of a great area, which pushes south as far as Manhattan Island, whose gneissoid rocks compose it, and eastward over the western half of Connecticut. In Massachusetts the archæan rocks bifurcate ; a finger reaches to the northern boundary of the State, where a thin connection exists with the great eastern region, and a shrunken area extends northward through the Berkshire Hills. The western limit of this latter strip lies some ten or fifteen miles from the eastern boundary of New York, and, entering Vermont at its southeastern border, widens out till, at Montpelier, almost half the State is covered. Slowly broadening thence, we follow its outlines into Canada, approach the St. Lawrence, and then, with an abrupt eastward deflection, trace it in a sinuous tongue until it touches the river at Mount Camille. The large eastern seaboard area of archæan rocks commences at Saybrook, on Long Island Sound, whence northward, limited by a sweeping curve, it covers the eastern part of

Connecticut, almost all of Rhode Island, and eastern Massachusetts, with some slight exceptions, where islands of later rock occur, as southwest from Boston and about Lowell. Nearly all New Hampshire is covered by it, and in Canada it forms another strip parallel to the first, while eastward it constitutes the surface rock of much of Maine, wherein, at last, it breaks up into scattered patches, lying like Titanic stepping-stones, from Augusta northward to the desolate horn of Newfoundland. One of these districts surrounds Mount Katahdin ; another, in a long, easterly-deflected strip of land, runs from Mount Desert northward to Chaleur Bay, New Brunswick ; while from Machias Bay a third streams northward in a narrow ribbon.

Separated areas are found along the southern shore of Newfoundland and upon Cape Breton Island.

In the United States four other extensive archæan territories exist east of 95° west longitude ; one in the Adirondack region, embracing the immense northern park of New York as far north as Malone, and stretching southward almost to Saratoga Springs, bordered by the State line, and, linking, through a narrow aperture between surfaces of subsequent strata, with the enormous reaches of azoic land which form Quebec and Ontario Provinces, it merges into two lateral expansions, on one side into the limitless highlands of Labrador, on the other into the ridges, valleys, and plateaus of the lake country northward to the Arctic Circle.

The second area is in northern Wisconsin and Michigan, embracing the Marquette region, famous for its ores. The third is a neighboring and related province in eastern Minnesota, from the South Bend on the Minnesota River, widening northward and uniting with the Canadian area about the Rainy Lake region. The fourth, a diminutive outlier, comprises the Iron Mountain and Pilot Knob country in southeast Missouri.

These large spaces of archæan rock represent the floor-layers, as now exposed in the eastern United States, of the continent's superstructure. In these parts of our country they form the surface-rock, and whether they have been always raised beyond the reach of sedimentary deposit or have been scoured and relieved by frost and flood of superincumbent strata, whether their present extent is conterminous with their limits, as once revealed above the level of primeval seas, or whether shrunken by subsidence and partially obliterated by later formations, they are at any rate outcrops of the vast bedding on which ocean and continent alike repose. But when we examine these aged stones we find that they themselves appear as the cemented residues and stratified deposits formed from some yet preëxistent firmament of land. In serial bands, conforming to each other, as book lies against book, we find limestone, slates, sandstones, quartzites, schists, and gneiss, and we know now that these regular layers, hard, distinct, and characterized by color, constituents, and adventitious minerals, were

once water-drifted beds *metamorphosed*, transfigured, as it were, by heat and pressure into this adamantine pavement; and, further, we find that they must have been so formed in the attrition and decay of yet older continents. The dim perspective opens backward to the very verge of chaos.

After deposition, and in a somewhat consolidated state, they were slowly raised, their emergence above the water accompanied a contraction of the earth's crust, and the flexible series, from top to bottom, folded up in deep and multiplied plications. Mountain-chains arose, their strata tilted up, contorted and complicated in related groups of synclinal and anticlinal axes, and, by the effective agency of heat and aqueous distillation through the myriad pores of the rock, a mineralogical change ensued. The argillaceous muds were hardened into slates and schists, the calcareous shoals became crystalline limestones, marbles, and dolomites, the siliceous bands became quartzites and sandstones, the iron slime crystallized into colossal sheets of iron-ore, magnesian sediments became serpentine, and through all there developed beautiful minerals under various associations and marking different horizons in this complex pile of natural masonry. Feldspars, pyroxene, mica, apatite, chondrodite, epidote, and garnet are a few of many which, in crevice and seam, and scattered through the matrix rock, remain as token, and possibly revelation, of the changes here enacted. From this archæan country come the magnetic oxide of the Adirondacks, the hematite of Marquette, the soft lead of Ticonderoga, the dolomite of Westchester County, the mica of North Carolina, the syenites and granites of Maine, the marbles of Vermont, the tinstone of New Hampshire, and the phosphates of Canada. Over thirty thousand feet in vertical thickness is the estimated depth of this gigantic mass —fitting foundation for the arches of the world.

Recent study, notably that of Dr. T. Sterry Hunt, separates this wonderful epoch into four secondary ones of unequal duration and varying character. First, the Laurentian, a name given by the Geological Survey of Canada and applied originally to the rocks of the Laurentian highlands, those abraded swells of land which overlook the St. Lawrence and rise in rugged grandeur four thousand feet high above the shadowed waters of the Saguenay. This primitive tract of archæan territory embraces the Adirondacks of New York, the region about Ottawa, portions of Newfoundland, and probably includes the rock assigned to this age in Massachusetts, Connecticut, and Rhode Island, and the long back which makes up the Highlands of the Hudson, the South Mountain of New Jersey, and the ridges about Richmond and Mount Roan in North Carolina. The rock is "a strong, massive gneiss, reddish or grayish in color."

Following this is the Norian, unconformable with the Laurentian, viz., not fitting into it, as though the latter, first made under water, solidified and raised, had again been depressed and received these sec-

ondary deposits. The Norian rock is distinguished by the abundance of labradorite, a feldspar possessing iridescent tints, and is found in Essex County, New York, Labrador, extensively along the St. Lawrence, upon Lake Huron, while "bowlders of it are occasionally found along the eastern shores of Maine and Massachusetts, and also in northern New Jersey."

The Huronian era succeeds, and is a name applied to the upper layers of the Huron Mountains, Lake Superior, to the Green Mountain series, and to detached areas along the coast of Newfoundland, eastern New England, and southward upon the flanks of the Blue Ridge. The Mont Alban series marks the fourth period, so named after the White Mountain layers in New Hampshire, where the aggregated display of crystalline schist is assigned to this province. New York, Philadelphia, Baltimore, and Washington occupy this *terrain*, and these rocks occur throughout the Blue Ridge, as far as Georgia, of more than passing significance, as they form the gold-bearing strata in Virginia, North and South Carolina. In these rocks the garnet, staurolite, cyanite, and chiastolite, favorites of the mineralogist, are almost exclusively found.

Instinctively we ask: Did no living thing exist through all these ages; did the mechanical wear and tear of rock-masses and their redeposition by mechanical means solely occupy the desolate centuries? The proofs of organic activity, involving the functions of life, are numerous, but the exact character of that life and the special conditions under which it flourished are greatly if not entirely wanting. In the first place, we find in Canada important, indeed inexhaustible deposits of carbon under the form of graphite, and graphite occurs in our coal-measures as the direct product of alteration from coal. These huge masses, distributed in pockets, sheets, and nodules through the archæan rock, indicate the presence of vegetative forces, doubtless exhibited in plants of a low order, but on a scale of tropical exuberance.

These carbon pockets occupy the shrunken areas of what were once vast, waving, and deeply matted beds of algæ, sea-weeds, building up, through innumerable generations amid the gathered detritus of shore and cliff, dense piles of carbonaceous remains. Or else they are attributable to a fertile growth of lichens which spread, possibly with an almost arborescent vigor, over plain and mountain. These organisms are low in the vegetable hierarchy, and along with them may have lived allied families: the microscopic Desmids and Diatoms, whose siliceous tests showered down through the still oceans; beside them the Corallines and Nullipores, forming calcareous fringes and coral-like thickets; the minute Protophytes and the delicate Charæ. Doubtless this age marked the climax of these plants, and, through multiplied species and in vast numbers, they represented one phase of the ever-restless evolution of vital forces.

The great deposits of iron-ore, though affording no direct evidence

in their remains of plant-life, are no less trustworthy proofs of its existence. They are themselves largely the result of vegetation in some form. Dr. Hunt originally explained this connection, illustrating it by identical processes in the world about us. If the reader visits a bog-land in summer, where slowly-running or stagnant water collects in pools, or if he stands upon the edge of a morass or marsh, he will notice angular, iridescent films floating upon the surface. They are thin pellicles of iron oxide, which will soon break up and sink, to be succeeded by fresh "skins," which in turn disappear, building up a growing layer of bog-iron ore beneath the water. The theory is simple. Iron exists under two forms, a soluble or monoxide, and an insoluble or sesquioxide. The latter is widely disseminated through the rocks and soils. The insoluble modification is reduced to the monoxide or soluble state in the presence of finely divided and rotting vegetable matter, or in water charged with vegetable infusions, as emacerated leaves and tissues. Rains and streams carry it away to lowlands and depressions, where it becomes, through contact with the air, again oxidized or rendered insoluble, and is redeposited in streaks and bands. The widespread action of vegetable acids is here concerned. Humic, crenic, apocrenic, and related acids, in conjunction with the reducing power of carbonaceous residues, removed iron oxide from the original rocks, and through the agency of water gathered it—useless as long as it remained scattered in minute particles through vast *terrains*—into enormous masses, the source and maintenance of our industries, thus garnered through these gentle and silent methods. Such has been the growth of the large deposits in the Marquette region, in the Adirondacks, and at Pilot Knob—deposits which under the influence of heat have become changed into the specular ores, the magnetites, and hematites. They point unmistakably to the existence of plants, and no less to their duration over immense periods of years.

The proofs of animal life are less satisfactory, and have been discredited in high scientific writings, or, more accurately, the morphological types of that life have been rejected, leaving the general presumption unquestioned that animal life of some kind prevailed. In the first place, the phosphatic minerals found in the archæan rocks are considered derivative from organic remains, as to-day phosphorus as a phosphate results from animal secretions, though phosphorus is omnipresent in the plant-world, and the ashes of various vegetables yield from eight per cent. to fifty-three per cent. of phosphoric acid, while the annual shipment of flour and wheat from our shores represents thousands of tons of this element. In this respect the evidence does not seem altogether controlling that these archæan phosphates necessarily resulted from animal *débris*. But the argument rests upon surer grounds. In 1865, Logan, Dawson, Carpenter, and Hunt, prepared a paper of great merit upon an archæan fossil, which they named *Eozoön*, and which they considered representative of the zoölogical sub-king-

dom of the Protozoa and allied to Foraminifera. They represent it as an organism attaching itself by a gelatinous body to sea-floors, enveloping itself with a crust of carbonate of lime in which very small tubes penetrated to the surface through which the sarcodous material within projected in tapering fingers, to be withdrawn at the will of the animal; upon this another layer of protoplastic matter, formed in the growth of the creature, connected with the first, but separated throughout most of its extent by an interlamination of limestone, in which radiating canals are discerned, and which succeeds the earlier poriferous shell. Upon this new calcareous crusts arise, and thus a cellular and tuberiferous mound is formed, compacted and regular, along the base of attachment, but loose, granulated, and divergent at its summit.

In our present seas closely related organisms appear, the Rhizopods, minute bodies, structureless, mere pellets of protoplasm, yet possessed of a secretive function which incases them in exquisitely symmetrical houses of lime. They are naturally low in the animal scale, indeed primary, and the Eozoön seems to have been a Titan progenitor of these hosts of later protozoans whose numberless fragments form the chalk-beds of England and France.

The *Eozoön Canadense* is found in the Laurentian rocks of Canada, other species in the Huronian of Bavaria, and specimens have been described from the Adirondacks and from Massachusetts. Forms strikingly resembling Eozoön may be found in the serpentine ledge in Fifty-ninth Street, near Tenth Avenue, New York. The soft parts in the calcareous skeleton of this Rhizopod have been replaced by minerals, and on the resemblance, amounting almost to identity, between the Eozoön and certain mineral pseudomorphs are based the objections made to its acceptance as of organic origin. King and Rowney, of Dublin, and Möbius, of Germany, have very vigorously attacked it, and lately Roemer rejects it from the list of palæozoic fossils. But it seems impossible to doubt the reality of its animal arrangement. Professor Hitchcock thoughtfully observes in this connection as regards its resemblance to mineral replacements, "Inasmuch as these structures represent the higher efforts of the mineral kingdom in crystallization and the nearest approach to the inorganic world allowed by animal forms, it is not strange that the two extremes should resemble each other sufficiently to deceive practical observers."

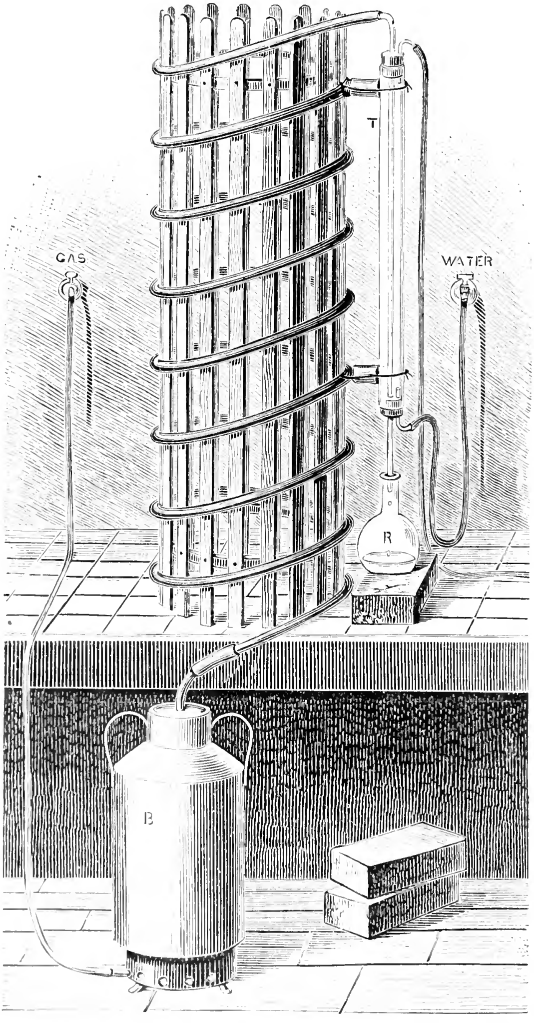
This was, in a few words, the archæan Continent. Its greatest area was in the north, with scattered islands and thin prolongations southward along the present axes of elevation. Subsequent periods built out from this and filled in the shadowy but prophetic sketch of North America—not an azoic or lifeless country, as once thought, yet a territory where silence reigned, broken only by the roar of the surf along its bleak margins, the whistle of the gale through its defiles, and the thunder of tempests upon its plains. "Lonely, silent, and impassive, heedless of man, season, or time, the weight of the Infinite seemed to brood over it."

NATURAL PRODUCTION OF ALCOHOL.*

By GASTON TISSANDIER.

M. A. MÜNTZ, of the French National Agronomical Institute, announces that he has discovered traces of alcohol as a natural product in cultivated soil, rain-water, sea- and river-water, and the atmosphere. He has detected the product, it is true, only in the most

Fig. 1.



infinitesimal quantities, but he has established the fact of its existence by analyses which are at once simple, clear, and convincing.

* Translated from "La Nature."

He has submitted to distillation some fifteen or twenty litres, or quarts, of snow-, rain-, or sea-water in the apparatus which is represented in Fig. 1. This apparatus consists of a milk-can, B, which is made to serve as a boiler, in which the liquid to be distilled is put. The vapors disengaged by the heat pass through a worm about thirty feet long, in which they are resolved ; thence through a tube incased in a refrigerating envelope, T, which is kept constantly cool by a current of cold water ; and are then condensed in the glass receiver, R. The operation is arrested as soon as one hundred or one hundred and fifty cubic centimetres of liquid—which will contain all the alcohol—have been condensed. The resultant liquid is again distilled in an

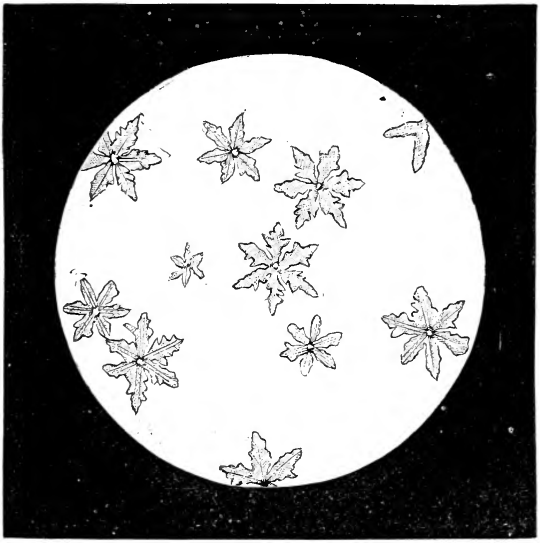


Fig. 2.—Crystals of Iodoform obtained by Synthesis (greatly magnified).

apparatus similar to the former one, but smaller. The latter operation is arrested when some five or six cubic centimetres of liquid have been condensed in a closed receiving-tube, which takes the place of the receiver R in the former apparatus. The tube is then taken away, and to its contents are added a little iodine and carbonate of soda ; on heating it slightly, small crystals are precipitated of iodoform, a substance which could not be produced unless alcohol were present. M. Müntz has verified the results of this process by other test experiments. When distilled water, chemically pure, was heated in the same apparatus, the addition of iodine and carbonate of soda was not followed by any reaction. A second verification was obtained by distilling fifteen litres of pure water, to which one millionth part of alcohol had been added ; the addition of iodine and carbonate of soda caused a precipitation of iodoform precisely like that which was ob-

tained in treating the natural waters. One or two hundred grammes (three and a half to seven ounces) of tilled earth mixed with a pint of

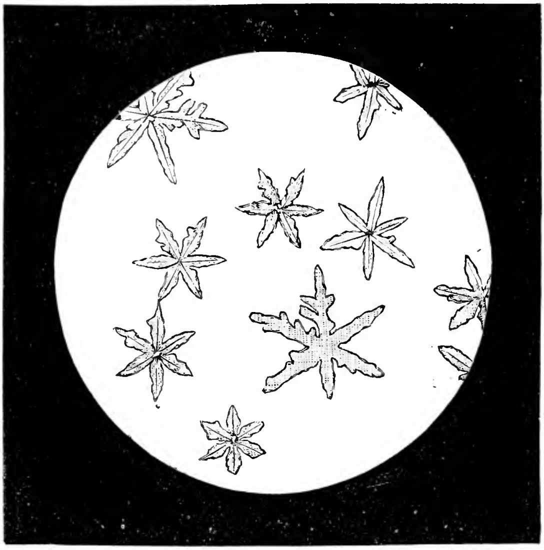


FIG. 3.—CRYSTALS OF IODOFORM OBTAINED WITH RAIN-WATER.

water gave a similar precipitate of iodoform when distilled and exposed to the reactions employed in the other experiments. The pre-

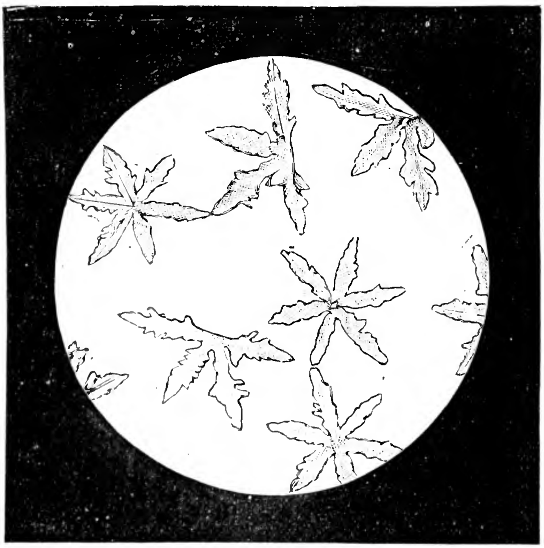


FIG. 4.—CRYSTALS OF IODOFORM OBTAINED WITH SNOW-WATER.

cipitation of iodoform by the addition of iodine and carbonate of soda is a very evident test of the presence of alcohol. Iodoform

has marked characteristics which permit it to be distinguished very readily: the form of its crystals, particularly, is typical; it is of a light yellowish color, and appears under the microscope in the form of six-rayed stars derived from an hexagonal prism, of precisely the form of snow-crystals. The accompanying figures give photographic representations of the crystals as they appear under the microscope. Fig. 2 represents the crystals from pure water to which alcohol has been added in the proportion of one millionth; Fig. 3, those obtained from rain-water; Fig. 4, crystals from snow-water; and Fig. 5, those procured from cultivated soil. M. Müntz's first experiments were made about four years ago. He has since examined a

Fig. 5.—Crystals of Iodoform obtained with Cultivated Soil.

considerable number of samples of rain- and snow-water from Paris and the country. After each distillation the apparatus has been carefully cleansed by exposing it for some time to currents of vapor, and the analysis has been tested by repeating it in blank. More than eighty essays have given identical results. The quantity of alcohol contained in rain-, snow-, and sea-water may be estimated at from one to several millionths of the whole. Cold water and snow-water seem to contain a little larger proportion of it than warm water. Appreciable quantities of it are found in the water of the Seine; and the proportion is very sensibly increased in sewer-water. Vegetable mold appears to be rich in it; and it is probable that the natural alcohol originates in the soil from the fermentation of the organic matters contained in it, and is thence diffused as a vapor in the atmo-

sphere. Meteoric waters absorb it at the moment of their condensation. These results are absolutely new, to our knowledge, and are the fruits of an entirely original labor.

THE MODERN DEVELOPMENT OF FARADAY'S CONCEPTION OF ELECTRICITY.*

By Professor H. HELMHOLTZ.

THE majority of Faraday's own researches were connected, directly or indirectly, with questions regarding the nature of electricity, and his most important and most renowned discoveries lay in this field. The facts which he has found are universally known. Nevertheless, the fundamental conceptions by which Faraday has been led to these much-admired discoveries have not been received with much consideration. His principal aim was to express, in his new conceptions, only facts, with the least possible use of hypothetical substances and forces. This was really a progress in general scientific method, destined to purify science from the last remnants of metaphysics. Now that the mathematical interpretation of Faraday's conceptions regarding the nature of electric and magnetic force has been given by Clerk Maxwell, we see how great a degree of exactness and precision was really hidden behind his words, which to his contemporaries appeared so vague or obscure; and it is astonishing in the highest degree to see what a large number of general theories, the methodical deduction of which requires the highest powers of mathematical analysis, he has found, by a kind of intuition, with the security of instinct, without the help of a single mathematical formula.

The electrical researches of Faraday, although embracing a great number of apparently minute and disconnected questions, all of which he has treated with the same careful attention and conscientiousness, are really always aiming at two fundamental problems of natural philosophy: the one more regarding the nature of physical forces, or of forces working at a distance; the other, in the same way, regarding chemical forces, or those which act from molecule to molecule, and the relation between these and the first.

The great fundamental problem which Faraday called up anew for discussion was the existence of forces working directly at a distance without any intervening medium. During the last and the beginning of the present century the model after the likeness of which nearly all physical theories had been formed was the force of gravitation acting

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between the sun, the planets, and their satellites. It is known how, with much caution and even reluctance, Sir Isaac Newton himself proposed his grand hypothesis, which was destined to become the first great and imposing example, illustrating the power of true scientific method.

But then came Oerstedt's discovery of the motions of magnets under the influence of electric currents. The force acting in these phenomena had a new and very singular character. It seemed as if it would drive a single isolated pole of a magnet in a circle around the wire conducting the current, on and on without end, never coming to rest. Faraday saw that a motion of this kind could not be produced by any force of attraction or repulsion, working from point to point. If the current is able to increase the velocity of the magnet, the magnet must react on the current. So he made the experiment, and discovered induced currents; he traced them out through all the various conditions under which they ought to appear. He concluded that somewhere in a part of the space traversed by magnetic force there exists a peculiar state of tension, and that every change of this tension produces electro-motive force. This unknown hypothetical state he called provisionally the electrotonic state, and he was occupied for years and years in finding out what was this electrotonic state. He discovered at first, in 1838, the dielectric polarization of electric insulators, subject to electric forces. Such bodies show, under the influence of electric forces, phenomena perfectly analogous to those exhibited by soft iron under the influence of the magnetic force. Eleven years later, in 1849, he was able to demonstrate that all ponderable matter is magnetized under the influence of sufficiently intense magnetic force, and at the same time he discovered the phenomena of diamagnetism, which indicated that even space, devoid of all ponderable matter, is magnetizable; and now, with quite a wonderful sagacity and intellectual precision, Faraday performed in his brain the work of a great mathematician without using a single mathematical formula. He saw with his mind's eye that, by these systems of tensions and pressures produced by the dielectric and magnetic polarization of space which surrounds electrified bodies, magnets or wires conducting electric currents, all the phenomena of electro-static, magnetic, electro-magnetic attraction, repulsion, and induction could be explained, without recurring at all to forces acting directly at a distance. This was the part of his path where so few could follow him; perhaps a Clerk Maxwell, a second man of the same power and independence of intellect, was necessary to reconstruct in the normal methods of science the great building, the plan of which Faraday had conceived in his mind and attempted to make visible to his contemporaries.

Nevertheless, the adherents of direct action at a distance have not yet ceased to search for solutions of the electro-magnetic problem. The present development of science, however, shows, as I think, a

state of things very favorable to the hope that Faraday's fundamental conceptions may in the immediate future receive general assent. His theory, indeed, is the only existing one which is at the same time in perfect harmony with the facts observed, and which at least does not lead into any contradiction against the general axioms of dynamics.

It is not at all necessary to accept any definite opinion about the ultimate nature of the agent which we call electricity.

Faraday himself avoided as much as he could giving any affirmative assertion regarding this problem, although he did not conceal his disinclination to believe in the existence of two opposite electric fluids.

For our own discussion of the electro-chemical phenomena, to which we shall turn now, I beg permission to use the language of the old dualistic theory, because we shall have to speak principally on relations of quantity.

I now turn to the second fundamental problem aimed at by Faraday, the connection between electric and chemical force. Already, before Faraday went to work, an elaborate electro-chemical theory had been established by the renowned Swedish chemist, Berzelius, which formed the connecting link of the great work of his life, the systematization of the chemical knowledge of his time. His starting-point was the series into which Volta had arranged the metals according to the electric tension which they exhibit after contact with each other. A fundamental point which Faraday's experiment contradicted was the supposition that the quantity of electricity collected in each atom was dependent on their mutual electro-chemical differences, which he considered as the cause of their apparently greater chemical affinity. But, although the fundamental conceptions of Berzelius's theory have been forsaken, chemists have not ceased to speak of positive and negative constituents of a compound body. Nobody can overlook that such a contrast of qualities, as was expressed in Berzelius's theory, really exists, well developed at the extremities, less evident in the middle terms of the series, playing an important part in all chemical actions, although often subordinated to other influences.

When Faraday began to study the phenomena of decomposition by the galvanic current, which of course were considered by Berzelius as one of the firmest supports of his theory, he put a very simple question; the first question, indeed, which every chemist speculating about electrolysis ought to have answered. He asked, What is the quantity of electrolytic decomposition if the same quantity of electricity is sent through several electrolytic cells? By this investigation he discovered that most important law, generally known under his name, but called by him the law of definite electrolytic action.

Faraday concluded from his experiments that a definite quantity of electricity can not pass a voltametric cell containing acidulated water between electrodes of platinum without setting free at the negative electrode a corresponding definite amount of hydrogen, and at the

positive electrode the equivalent quantity of oxygen, one atom of oxygen for every pair of atoms of hydrogen. If, instead of hydrogen, any other element capable of substituting hydrogen is separated from the electrolyte, this is done also in a quantity exactly equivalent to the quantity of hydrogen which would have been evolved by the same electric current.

Since that time our experimental methods and our knowledge of the laws of electrical phenomena have made enormous progress, and a great many obstacles have now been removed which entangled every one of Faraday's steps, and obliged him to fight with the confused ideas and ill-applied theoretical conceptions of some of his contemporaries. We need not hesitate to say that, the more experimental methods were refined, the more the exactness and generality of Faraday's law was confirmed.

In the beginning, Berzelius and the adherents of Volta's original theory of galvanism, based on the effects of metallic contact, raised many objections against Faraday's law. By the combination of Nobili's astatic pairs of magnetic needles with Schweigger's multiplicator, a coil of copper wire with numerous circumvolutions, galvanometers became so delicate that the electro-chemical equivalent of the smaller currents they indicated was imperceptible for all chemical methods. With the newest galvanometers you can very well observe currents which would want to last a century before decomposing one milligramme of water, the smallest quantity which is usually weighed on chemical balances. You see that, if such a current lasts only some seconds or some minutes, there is not the slightest hope to discover its products of decomposition by chemical analysis. And, even if it should last a long time, the feeble quantities of hydrogen collected at the negative electrode can vanish, because they combine with the traces of atmospheric oxygen absorbed by the liquid. Under such conditions a feeble current may continue as long as you like without producing any visible trace of electrolysis, even not of galvanic polarization, the appearance of which can be used as an indication of previous electrolysis. Galvanic polarization, as you know, is an altered state of the metallic plates which have been used as electrodes during the decomposition of an electrolyte. Polarized electrodes, when connected by a galvanometer, give a current which they did not give before being polarized. By this current the plates are discharged again and returned to their original state of equality.

This depolarizing current is indeed a most delicate means of discovering previous decomposition. I have really ascertained that under favorable conditions one can observe the polarization produced during some seconds by a current which decomposes one milligramme of water in a century.

Products of decomposition can not appear at the electrodes without motions of the constituent molecules of the electrolyte throughout the

whole length of the liquid. This subject has been studied very carefully, and for a great number of liquids, by Professor Hittorff, of Münster, and Professor G. Wiedemann, of Leipsic.

Professor F. Kohlrausch, of Würzburg, has brought to light the very important fact that, in diluted solutions of salts, including hydrates of acids and hydrates of caustic alkalies, every atom under the influence of currents of the same density moves on with its own peculiar velocity, independently of other atoms moving at the same time in the same or in opposite directions. The total amount of chemical motion in every section of the fluid is represented by the sum of the equivalents of the cation gone forward and of the anion gone backward, in the same way as in the dualistic theory of electricity, and the total amount of electricity flowing through a section of the conductor corresponds to the sum of positive electricity going forward and negative electricity going backward.

This established, Faraday's law tells us that, through each section of an electrolytic conductor, we have always equivalent electrical and chemical motion. The same definite quantity of either positive or negative electricity moves always with each univalent ion, or with every unit of affinity of a multivalent ion, and accompanies it during all its motions through the interior of the electrolytic fluid. This we may call the electric charge of the atom.

Now, the most startling result, perhaps, of Faraday's law is this: If we accept the hypothesis that the elementary substances are composed of atoms, we can not avoid concluding that electricity also, positive as well as negative, is divided into definite elementary portions, which behave like atoms of electricity. As long as it moves about on the electrolytic liquid, each atom remains united with its electric equivalent or equivalents. At the surface of the electrodes decomposition can take place if there is sufficient electro-motive power, and then the atoms give off their electric charges and become electrically neutral.

Now arises the question, Are all these relations between electricity and chemical combination limited to that class of bodies which we know as electrolytes? In order to produce a current of sufficient strength to collect enough of the products of decomposition without producing too much heat in the electrolyte, the substance which we try to decompose ought not to have too much resistance against the current. But this resistance may be very great, and the motion of the ions may be very slow—so slow indeed that we should need to allow it to go on for hundreds of years before we should be able to collect even traces of the products of decomposition; nevertheless, all the essential attributes of the process of electrolysis could subsist. If you connect an electrified conductor with one of the electrodes of a cell filled with oil of turpentine, the other with the earth, you will find that the electricity of the conductor is discharged unmistakably more

rapidly through the oil of turpentine than if you take it away and fill the cell only with air.

Also in this case we may observe polarization of the electrodes as a symptom of previous electrolysis. Another sign of electrolytic conduction is, that liquids brought between two different metals produce an electro-motive force. This is never done by metals of equal temperature, or other conductors which, like metals, let electricity pass without being decomposed.

The same effect is also observed even with a great many rigid bodies, although we have very few solid bodies which allow us to observe this electrolytic conduction with the galvanometer, and even these only at temperatures near to their melting-point. It is nearly impossible to shelter the quadrants of a delicate electrometer against being charged by the insulating bodies by which they are supported.

In all the cases which I have quoted one might suspect that traces of humidity absorbed by the substances or adhering to their surface were the electrolytes. I show you, therefore, this little Daniell's cell, in which the porous septum has been substituted by a thin stratum of glass. Externally, all is symmetrical at both poles ; there is nothing in contact with the air but a closed surface of glass, through which two wires of platinum penetrate. The whole charges the electrometer exactly like a Daniell's cell of very great resistance, and this it would not do if the septum of glass did not behave like an electrolyte. All these facts show that electrolytic conduction is not at all limited to solutions of acids or salts.

Hitherto we have studied the motions of ponderable matter, as well as of electricity, going on in an electrolyte. Let us study now the forces which are able to produce these motions. It has always appeared somewhat startling to everybody who knows the mighty power of chemical forces, the enormous quantity of heat and of mechanical work which they are able to produce, and who compares with it the exceedingly small electric attraction which the poles of a battery of two Daniell's cells show. Nevertheless, this little apparatus is able to decompose water.

The quantity of electricity which can be conveyed by a very small quantity of hydrogen, when measured by its electrostatic forces, is exceedingly great. Faraday saw this, and has endeavored in various ways to give at least an approximate determination. The most powerful batteries of Leyden-jars, discharged through a voltameter, give scarcely any visible traces of gases. At present we can give definite numbers. The result is, that the electricity of one milligramme of water, separated and communicated to two balls one kilometre distant, would produce an attraction between them equal to the weight of twenty-five thousand kilos.

The total force exerted by the attraction of an electrified body upon another charged with opposite electricity is always proportional

to the quantity of electricity contained in the attracting as on the attracted body, and therefore even the feeble electric tension of two Daniell's elements, acting through an electrolytic cell upon the enormous quantities of electricity with which the constituent ions of water are charged, is mighty enough to separate these elements and to keep them separated.

We now turn to investigate what motions of the ponderable molecules require the action of these forces. Let us begin with the case where the conducting liquid is surrounded everywhere by insulating bodies. Then no electricity can enter, none can go out through its surface, but positive electricity can be driven to one side, negative to the other, by the attracting and repelling forces of external electrified bodies. This process, going on as well in every metallic conductor, is called "electrostatic induction." Liquid conductors behave quite like metals under these conditions. Professor Wüllner has proved that even our best insulators, exposed to electric forces for a long time, are charged at last quite in the same way as metals would be charged in an instant. There can be no doubt that even electro-motive forces going down to less than $\frac{1}{100}$ Daniell produce perfect electrical equilibrium in the interior of an electrolytic liquid.

Another somewhat modified instance of the same effects is afforded by a voltametric cell containing two electrodes of platinum, which are connected with a Daniell's cell, the electro-motive force of which is insufficient to decompose the electrolyte. Under this condition the ions carried to the electrodes can not give off their electric charges. The whole apparatus behaves, as was first accentuated by Sir W. Thomson, like a condenser of enormous capacity.

Observing the polarizing and depolarizing currents in a cell containing two electrodes of platinum, hermetically sealed and freed of all air, we can observe these phenomena with the most feeble electro-motive forces of $\frac{1}{1000}$ Daniell, and I found that down to this limit the capacity of the platinum surfaces proved to be constant. By taking greater surfaces of platinum I suppose it will be possible to reach a limit much lower than that. If any chemical force existed besides that of the electrical charges, which could bind all the pairs of opposite ions together, and require any amount of work to be vanquished, an inferior limit to the electro-motive forces ought to exist, which forces are able to attract the atoms to the electrodes and to charge these as condensers. No phenomenon indicating such a limit has as yet been discovered, and we must conclude, therefore, that no other force resists the motions of the ions through the interior of the liquid than the mutual attractions of their electric charges.

On the contrary, as soon as an ion is to be separated from its electrical charge we find that the electrical forces of the battery meet with a powerful resistance, the overpowering of which requires a good deal of work to be done. Usually the ions, losing their electric charges,

are separated at the same time from the liquid; some of them are evolved as gases, others are deposited as rigid strata on the surface of the electrodes, like galvanoplastic copper. But the union of two constituents having powerful affinity to form a chemical compound, as you know very well, produces always a great amount of heat, and heat is equivalent to work. On the contrary, decomposition of the compound substances requires work, because it restores the energy of the chemical forces which has been spent by the act of combination.

Metals uniting with oxygen or halogens produce heat in the same way, some of them, like potassium, sodium, zinc, even more heat than an equivalent quantity of hydrogen; less oxidizable metals, like copper, silver, platinum, less. We find, therefore, that heat is generated when zinc drives copper out of its combination with the compound halogen of sulphuric acid, as is the case in a Daniell's cell.

If a galvanic current passes through any conductor, a metallic wire, or an electrolytic fluid, it evolves heat. Mr. Prescott Joule was the first who proved experimentally that, if no other work is done by the current, the total amount of heat evolved in a galvanic circuit during a certain time is exactly equal to that which ought to have been generated by the chemical actions which have been performed during that time. But this heat is not evolved at the surface of the electrodes, where these chemical actions take place, but is evolved in all the parts of the circuit, proportionally to the galvanic resistance of every part. From this it is evident that the heat evolved is an immediate effect, not of the chemical action, but of the galvanic current, and that the chemical work of the battery has been spent in producing only the electric action.

If we apply Faraday's law, a definite amount of electricity passing through the circuit corresponds to a definite amount of chemical decomposition going on in every electrolytic cell of the same circuit. According to the theory of electricity, the work done by such a definite quantity of electricity which passes, producing a current, is proportionate to the electro-motive force acting between both ends of the conductor. You see, therefore, that the electro-motive force of a galvanic circuit must be, and is, indeed, proportionate to the heat generated by the sum of all the chemical actions going on in all the electrolytic cells during the passage of the same quantity of electricity. In cells of the galvanic battery chemical forces are brought into action able to produce work; in cells in which decomposition is occurring work must be done against opposing chemical forces; the rest of the work done appears as heat evolved by the current, as far as it is not used up to produce motions of magnets or other equivalents of work.

Hitherto we have supposed that the ion with its electric charge is separated from the fluid. But the ponderable atoms can give off their electricity to the electrode and remain in the liquid, being now elec-

trically neutral. This makes almost no difference in the value of the electro-motive force. For instance, if chlorine is separated at the anode it will remain at first absorbed by the liquid ; if the solution becomes saturated, or if we make a vacuum over the liquid, the gas will rise in bubbles. The electro-motive force remains unaltered. The same may be observed with all the other gases. You see in this case that the change of electrically negative chlorine into neutral chlorine is the process which requires so great an amount of work, even if the ponderable matter of the atoms remains where it was.

The more the surface of the positive electrode is covered with negative atoms of the anion and the negative with the positive ones of the cation, the more the attracting force of the electrodes exerted upon the ions of the liquid is diminished by this second stratum of opposite electricity covering them. On the contrary, the force with which the positive electricity of an atom of hydrogen is attracted toward the negatively charged metal increases in proportion as more negative electricity collects before it on the metal and the more negative electricity collects behind it in the fluid.

Such is the mechanism by which electric force is concentrated and increased in its intensity to such a degree that it becomes able to overpower the mightiest chemical affinities we know of. If this can be done by a polarized surface, acting like a condenser, charged by a very moderate electro-motive force, can the attractions between the enormous electric charges of anions and cations play an unimportant and indifferent part in chemical affinity?

You see, therefore, if we use the language of the dualistic theory and treat positive and negative electricities as two substances, the phenomena are the same as if equivalents of positive and negative electricity were attracted by different atoms, and perhaps also by the different values of affinity belonging to the same atom, with different force. Potassium, sodium, zinc, must have strong attraction to a positive charge ; oxygen, chlorine, bromine, to a negative charge.

Faraday very often recurs to this to express his conviction that the forces termed chemical affinity and electricity are one and the same. I have endeavored to give you a survey of the facts in their mutual connection, avoiding, as far as possible, introducing other hypotheses, except the atomic theory of modern chemistry. I think the facts leave no doubt that the very mightiest among the chemical forces are of electric origin. The atoms cling to their electric charges and the opposite electric charges cling to the atoms. But I don't suppose that other molecular forces are excluded, working directly from atom to atom. Several of our leading chemists have begun lately to distinguish two classes of compounds, molecular aggregates and typical compounds. The latter are united by atomic affinities, the former not. Electrolytes belong to the latter class.

If we conclude from the facts that every unit of affinity of every

atom is charged always with one equivalent, either of positive or of negative electricity, they can form compounds, being electrically neutral, only if every unit charged positively unites under the influence of a mighty electric attraction with another unit charged negatively. You see that this ought to produce compounds in which every unit of affinity of every atom is connected with one and only with one other unit of another atom. This is, as you will see immediately, indeed, the modern chemical theory of quantivalence, comprising all the saturated compounds. The fact that even elementary substances, with few exceptions, have molecules composed of two atoms, makes it probable that even in these cases electric neutralization is produced by the combination of two atoms, each charged with its electric equivalent, not by neutralization of every single unit of affinity.

But I abstain from entering into mere specialties, as, for instance, the question of unsaturated compounds ; perhaps I have gone already too far. I would not have dared to do it if I did not feel myself sheltered by the authority of that great man who was guided by a never-erring instinct of truth. I thought that the best I could do for his memory was to recall to the minds of the men, by the energy and intelligence of whom chemistry has undergone its modern astonishing development, what important treasures of knowledge lie still hidden in the works of that wonderful genius. I am not sufficiently acquainted with chemistry to be confident that I have given the right interpretation—that interpretation which Faraday himself would have given, perhaps, if he had known the law of chemical quantivalence, if he had had the experimental means of ascertaining how large the extent, how unexceptional the accuracy of his law really is ; and if he had known the precise formulation of the law of energy applied to chemical work, and of the laws which determine the distribution of electric forces in space as well as in ponderable bodies, transmitting electric current or forming condensers. I shall consider my work of to-day well rewarded if I have succeeded in kindling anew the interest of chemists for the electro-chemical part of their science.

GLUCOSE AND GRAPE-SUGAR.

By Professor HARVEY W. WILEY.

THE manufacture of sirup and sugar from corn-starch is an industry which, in this country, is scarcely a dozen years old, and yet it is one of no inconsiderable magnitude. On August 1, 1880, ten glucose-factories were in operation in the United States, consuming daily about twenty thousand bushels of corn. These, with their several capacities, are as follows :

Firmenich's, Buffalo	4,000	bushels.
Buffalo, Buffalo	5,000	"
American, Buffalo	3,000	"
Higher, St. Louis	1,000	"
Peoria Refinery, Peoria	2,500	"
Peoria Grape-sugar, Peoria	850	"
Davenport, Davenport, Iowa	1,500	"
Freeport, Freeport, Illinois	1,500	"
Duryea, Brooklyn	1,500	"
Sagetown, Sagetown, Illinois	250	"

At that time, also, there were in process of construction nine factories, with a total capacity of twenty-two thousand bushels daily.

At the same time additional machinery was in process of erection in the two Peoria factories, which increased their capacity two thousand and twenty-five hundred bushels, respectively.

The new factories were building in—

Detroit	capacity,	3,000	bushels.
Chicago	"	10,000	"
Geneva, Illinois	"	1,000	"
Iowa City	"	1,500	"
Danville, Illinois	"	1,500	"
Tippecanoe, Ohio	"	500	"
Rockford, Illinois	"	1,000	"
Pekin, Illinois	"	500	"
Marshalltown, Iowa	"	3,000	"

We may safely assume that at the present time one half of these new factories are in running order. The total daily consumption of corn, therefore, for sugar- and sirup-making, is not far from thirty-five thousand bushels.

Eleven million bushels of corn during the present year will be used for this purpose, and every indication leads us to believe that the amount will be doubled in 1882.

The capital invested in this sugar industry is likewise no inconsiderable one. Taking the large and small establishments together, each thousand bushels of daily capacity represents sixty thousand dollars of capital. Over two million dollars are therefore actively employed in the glucose-works. The number of men employed amounts to about sixty for each thousand bushels capacity, making a total of twenty-one hundred. On account of the nature of the process of manufacture, the mills are run night and day, and work is not entirely suspended on Sunday.

To avoid confusion of ideas, the following statements seem necessary: The word *glucose*, in this country, is employed among dealers to designate exclusively the thick sirup which is made from corn-starch. On the other hand, *grape-sugar* is applied to the solid product obtained from the same source. The *glucose* and *grape-sugar* of the

trade have optical and chemical properties quite different from many other substances bearing the same name. I shall use the words in the signification explained above.

Properties of Glucose.—Glucose is a thick, tenacious sirup, almost colorless, or of a yellowish tint. It has an average specific gravity, at 20° C., of 1·412. That which is made for summer consumption is a little denser than that manufactured for winter use. This sirup is so thick that, in the winter, it is quite difficult to pour it from one vessel to another.

The sweetness of glucose—i. e., the intensity of the impression it makes on the nerves of taste—varies greatly with different specimens. Some kinds approach in intensity the sweetness of cane-sugar, while others seem to act slowly and feebly. It has been shown that the degree of sweetness depends on the extent of the chemical changes which go on in the conversion of starch into sugar. When the process of conversion is stopped as soon as the starch has disappeared, the resulting glucose has a maximum sweetness.* The color of glucose depends on the thorough washing of the substance, during the process of manufacture, through animal charcoal, and lowness of temperature at which it is evaporated, and rapidity of evaporation. The methods of securing these conditions will be described further on.

There is one variety of glucose which is made for confectioners' use, which is much thicker and denser than that just described. Its specific gravity may reach 1·440, but it has no tendency to become hard and solid, like the so-called grape-sugar.

The grape-sugar made from corn-starch, when well made, is pure white in color when first made, but has a tendency to assume a yellowish tint when old. It is hard and brittle, does not usually take on a visible crystalline structure, and is less soluble in water than cane-sugar. Perhaps it would be more accurate to say that it dissolves more slowly, since both cane- and grape-sugar dissolve in all proportions in hot water. I have found its specific gravity to be as high as 1·6. It is much less sweet to the taste than glucose, and a faint bitter after-taste is to be perceived.

Uses of Glucose and Grape-Sugar.—Glucose is used chiefly for the manufacture of table-sirups, candies, as food for bees, for brewing, and for artificial honey.

It is impossible at present to get any reliable statistics concerning the amount of glucose used in beer-making. The brewers themselves try to keep its use a secret, since it is quite common to proclaim that beer is made from barley and hops alone, although this is rarely the case. Dealers and manufacturers are likewise reticent when approached on this subject, since it is but natural for them to wish to protect the interests of their patrons. We shall not go far wrong, however, when

* See paper read by the author at the Boston meeting of the American Association for the Advancement of Science.

we say that the amount of glucose used by brewers is by no means small, and that the quantity is constantly increasing. I do not know any reason why its moderate use should injure the quality of the beer.

Bees eat glucose with the greatest avidity, or, rather, they act as funnels by which the glucose is poured into the comb. For it is quite true that honey made by bees which have free access to glucose differs scarcely at all from the glucose itself. But the quantity of honey which a bee will store away when fed on glucose is truly wonderful. This gluttony, however, rapidly undermines the apiarian constitution, and the bee rarely lives to enjoy the fruits of its apparent good fortune. In commercial honey, which is entirely free from bee mediation, the comb is made of paraffine, and filled with pure glucose by appropriate machinery. This honey, for whiteness and beauty, rivals the celebrated real white-clover honey of Vermont, but can be sold at an immense profit at one half the price.

All soft candies, waxes, and taffies, and a large proportion of stick-candies and caramels, are made of glucose. Very often a little cane-sugar is mixed with the glucose, in order to give a sweeter taste to the candies, but the amount of this is made as small as possible. As has been stated above, the glucose which is used in confections is evaporated nearer to dryness than that which is used for sirups. In such glucoses I have found the percentage of water to be as low as 6·37. Such a product is almost thick enough for "taffy" without any further concentration.

A very large percentage of all the glucose made is used for the manufacture of table-sirups. The process of manufacture is a very simple one:

The glucose is mixed with some kind of cane-sugar sirup until the tint reaches a certain standard. The amount of cane-sugar sirup required varies from three to ten per cent., according to circumstances. These sirups are graded A, B, C, etc., the tint growing deeper with each succeeding letter.

When these sirups are sent into the shops, they are sold to consumers under such altisonant names as "Maple Drip," "Bon Ton," "Upper Ten," "Magnolia," "Extra Choice," "Golden Drip," "White-Loaf Drip," etc. Dealers tell me that these sirups, by their cheapness and excellence, have driven all the others out of the market. So much is this the case that it is no longer proper to call glucose the "coming sirup." It is the sirup which has already come.

In addition to the uses above mentioned, small quantities of glucose are used by vinegar-makers, tobacconists, wine-makers, distillers, mucilage-makers, and perhaps for some other purposes.

Grape-sugar is also used for many of the purposes enumerated above, but chiefly for the adulteration of other sugars. When it is reduced to fine powder, it can be mixed with cane-sugar in any proportions, without altering its appearance. Since the grape-sugar costs less than

half the price of cane-sugar, this adulteration proves immensely profitable. The presence of grape-sugar in table-sugars can be approximately determined by several simple tests. When placed on the tongue, the bitter after-taste, already spoken of, may be detected. If spread in a thin layer on a piece of glass, and treated with a little water, the cane-sugar granules dissolve first, and the grape-sugar is left as a flocculent mass. With the microscope, its particles can be detected by the absence of all crystalline structure. Its exact quantity can only be determined by the polariscope. This is hardly a proper place to describe how this is done.

From the best information I can obtain, it appears that the cost of manufacture of glucose and grape-sugar is about one cent a pound. From twenty-six to thirty-two pounds are made from a bushel of corn. It is sold by the manufactories at three to four cents per pound. In the West the price of corn during the last year has averaged a little over thirty cents per bushel. It thus appears that the manufacture of glucose is a profitable industry.

I shall attempt here no detailed statement of the method of manufacture, but give only such an outline as may interest those who like to know how the things on their tables are prepared. The corn is first soaked for two or three days in warm water, and is then ground on specially prepared stones with a stream of water. The meal is next passed into a trough, the bottom of which is made of fine bolting-cloth. Here the starch is washed through, and led to large tanks, where it is allowed to settle. It is next beaten up with caustic soda to separate the gluten, and the starch is again allowed to settle in long, shallow troughs. The starch, washed from all adhering alkali, is next beaten up with water into a cream, and conducted into the converting-tubs. These tubs are supplied with coils of copper steam-piping and are made of wood. Here the starch-cream is treated with dilute sulphuric acid, and steam is allowed to bubble up through the mixture from small holes in the copper pipes. This process of conversion, which is called "open conversion," is completed in about two hours.

Another method is called "close conversion." The substances are inclosed in stout copper cylinders, and subjected to the action of superheated steam. This process occupies about fifteen minutes.

The conversion is also accomplished sometimes by fermentation. This requires a much longer time. The greater part of it, however, is carried on by the method first named.

After conversion the acid is neutralized by marble-dust and animal charcoal. Since the sulphate of calcium, which is formed in this operation, is slightly soluble in water, carbonate of barium has been used instead of marble-dust. Its use, however, has not become general.

After neutralization the liquid is filtered through cloth and animal charcoal, and is then conveyed to the vacuum-pan. Here it is evapo-

rated, at as low a temperature as possible, to the required concentration. If grape-sugar is to be made, the process of conversion is not stopped as soon as the starch has disappeared, but is carried on still further to a point which can only be determined by trial. After concentration it is conveyed into tanks, where the process of solidification begins and continues for several days.

Glucose, on the other hand, will not harden, whatever the degree of concentration may be, or, at least, if it do so, only partially and after many months.

The habit of bleaching both glucose and grape-sugar by means of sulphurous acid is sometimes practiced, but is reprehensible. By the oxidation of the sulphurous acid, free sulphuric acid is likely to occur in the finished product.

Glucose and grape-sugar are mixtures of several chemical substances. Starch, which is composed of six atoms of carbon, ten of hydrogen, and five of oxygen, when subjected to the action of dilute sulphuric acid, appears to undergo a molecular condensation and hydration. Among the substances formed may be reckoned dextrine, glucose, and a substance isomeric with cane-sugar. This latter substance appears to be one of the early products of conversion, and this is the reason that the poorly converted glucoses are sweeter than the well converted. It is only after prolonged boiling with dilute acid that the product becomes chemically homogeneous, with a constitution which is probably represented by the symbol $C_6H_{12}O_6H_2O$.

Glucose presents several anomalies when examined with polarized light. Its highest rotatory power is found when it is made with the least possible amount of conversion—i. e., when the process of conversion is stopped as soon as the starch has disappeared. Continued boiling with dilute acid causes a gradual decrease of rotatory power. It is only after six to eight hours' heating to a temperature of 104° C. that a constant rotatory power is reached. This power is only about half that exhibited by the glucose as a maximum. This minimum rotatory power, however, is greater than that possessed by cane-sugar.

Glucose, like many other bodies, has the property of reducing a hot alkaline copper solution and separating the metal as a red sub-oxide. This power in glucose is always inversely as the rotating power. I have shown this fully and conclusively in the paper already referred to. The relation between reducing power and rotating power is a constant one, and hence the percentage of reducing power can be calculated from the polarimetric observations. This, however, is of more interest to the practical chemist than to the general reader, and I therefore pass it by.

The question of most practical importance is, "Is glucose a wholesome article of food?" I do not hesitate to answer this question in the affirmative. I mean by this, however, a glucose which is properly made. Such a glucose contains only a very little sulphuric

acid and lime, not much more than good spring-water, and perhaps an almost infinitesimal trace of copper, so slight as only to be detected in a large quantity of the substance. I do not doubt but that glucoses have been sold which contain large quantities of free sulphuric acid and likewise other injurious ingredients. But these are due to carelessness in manufacture, and are not constituents of the genuine article. I have never found a glucose of this kind. Many of the impurities which have been imputed to glucose, really belong to the cane-sirups with which they have been mixed. These largely adulterated glucoses should always be looked upon with suspicion. The cane-sirups, which are used for this purpose, yield from three to five per cent. of ash, while the ash from a genuine glucose is so little as to be almost unweighable.

There is no reason to believe that a glucose or grape-sugar properly manufactured is any less wholesome than cane- or maple-sugar. Corn, the new American king, now supplies us with bread, meat, and sugar, which we need, as well as with the whisky which we could do without.

THE MENTAL EFFECT OF EARTHQUAKES.

THE outbreak of new earthquakes, first at Agram, then in Ischia, and now in Chios, the last the most destructive of all, and costing thousands of lives, within a few weeks of each other, seems to show that a period of earthquake-shock may have begun which may affect, to an extent by no means inconsiderable, the history and life of our century. No one can doubt that the earthquakes and volcanic eruptions which visited the same general region, but more especially Asia Minor and Italy, during the first and second centuries of our era, produced great effects, not only on the minds and characters of that generation, but even on the distribution of population ; nor that the earthquake at Lisbon, in the last century, produced almost as great a shock on the thoughts of men as it produced physically on the immense region over which its effects were felt—a region which included almost all Europe, part of Africa, and part of the American Continent. A spell of earthquake of any violence or duration, which should extend over such a field as that, would, in a time like our own, when every influence is intensified by the simultaneous transmission of the impressions it produces to all parts of the globe, produce the most powerful effects, not simply on the countries which might suffer from it, but on all the world. No physical phenomena, however dreadful, seem to produce the same sense of paralysis as earthquakes. A correspondent of Captain Basil Hall, who was in the earthquake of Copiapo,

in 1822, describes the effect on the mind as something which begins before any other sign of the earthquake has manifested itself at all—an anticipatory horror, which is even more marked in the case of the lower animals. "Before we hear the sound, or at least are fully conscious of hearing it, we are made sensible, I do not know how, that something uncommon is going to happen; everything seems to change color; our thoughts are chained immovably down; the whole world appears to be in disorder; all nature looks different to what it is wont to do; and we feel quite subdued and overwhelmed by some invisible power, beyond human control or apprehension." In the Neapolitan earthquake of 1805, these anticipatory signs were most remarkable in relation to the life of the animal world. An Italian writer, quoted in Mr. Wittich's "Curiosities of Physical Geography," says: "I must not omit in this place to mention those prognostics which were derived from animals. They were observed in every place where the shocks were such as to be generally perceptible. Some minutes before they were felt, the oxen and cows began to bellow, the sheep and goats bleated, and, rushing in confusion one on the other, tried to break the wicker-work of the folds; the dogs howled terribly, the geese and fowls were alarmed and made much noise; the horses which were fastened in their stalls were greatly agitated, leaped up, and tried to break the halters with which they were attached to the mangers; those which were proceeding on the roads suddenly stopped, and snorted in a very strange way. The cats were frightened, and tried to conceal themselves, or their hair bristled up wildly. Rabbits and moles were seen to leave their holes; birds rose, as if scared, from the places on which they had alighted; and fish left the bottom of the sea and approached the shores, where at some places great numbers of them were taken. Even ants and reptiles abandoned, in clear daylight, their subterranean holes in great disorder, many hours before the shocks were felt. Large flights of locusts were seen creeping through the streets of Naples toward the sea the night before the earthquake. Winged ants took refuge during the darkness in the rooms of the houses. Some dogs, a few minutes before the first shock took place, awoke their sleeping masters, by barking and pulling them, as if they wished to warn them of the impending danger, and several persons were thus enabled to save themselves." What it is, before the sound or shock of earthquake is felt, which warns both animals and human beings of the approach of some dreadful catastrophe threatening the very basis of their existence, no one, of course, can say, since the impression made upon the nervous system is, at least as regards our own species, evidently one of general disturbance, and not one to which experience attaches any explicit significance. It may be, of course, that some very great change in the magnetic conditions of a spot threatened with earthquake leads to that extreme excitement of mind exhibited by all living creatures previous to the onset of the

earthquake. That, however, is pure conjecture. What is interesting is, that a certain blank consternation seems always to be the characteristic herald of an earthquake, as well as the characteristic result. That it should be the characteristic result is, of course, no wonder. The very condition of human life is the solidity of the not very thick earth-crust on which we live, and when that solidity is exchanged for positive fluidity, as it is in the worst earthquakes, it is natural enough that stupefaction should be the result. In one of the Calabrian earthquakes, it was discovered that large pieces of ground had so changed places that a plantation of mulberry-trees had been carried into the middle of a corn-field and there left, and a field sown with lupines had been carried out into the middle of a vineyard. The Italian lawsuits which resulted from this liquefaction of "real" property may be easily imagined. Still stranger, in the earthquake in Riobamba in 1797, Alexander von Humboldt found that the whole furniture of one house had been buried beneath the ruins of the next house. "The upper layer of the soil, formed of matter not possessing a great degree of coherency, had moved like water in running streams, and we are compelled to suppose that those streams flowed first downward, and at last rose upward. The motion in the shocks which were experienced in Jamaica (July 7, 1692) must have been not less complicated. According to the account of an eye-witness, the whole surface of the ground had assumed the appearance of running water. The sea and land appeared to rush on one another, and to mingle in the wildest confusion. Some persons who, at the beginning of the calamity, had escaped into the streets and to the squares of the town, to avoid the danger of being crushed under the ruins of the falling houses, were so violently tossed from one side to the other that many of them received severe contusions, and some were maimed. Others were lifted up, hurled through the air, and thrown down at a distance from the place where they were standing. A few who were in town were carried away to the seashore, which was rather distant, and then thrown into the sea, by which accident, however, their lives were saved." Such a liquefaction of all that is most solid in our world seems a grim enough realization of the prayer of the prophet: "O that thou wouldst rend the heavens, that thou wouldst come down, that the mountains might flow down at thy presence," for the mountains do really flow down in earthquakes, but the effect of that flowing is a consternation such as no other phenomenon of physical life, not even the worst darkness of volcanic eruptions, ever produces. The loss of everything stable at the basis of human life is the collapse of the ordinary foundations even of the spiritual life itself, though, if that life has got its roots firmly into the heart, the original foundations may fall away without impairing the vitality of that which at first had propped itself upon them. But, where this is not the case, nothing tends more to that truest Nihilism—which, so far from thinking it

worth while to destroy anything, finds both destruction and construction alike childish under the tottering of the very pillars of life—than the phenomena of an earthquake. Amid the moral shocks which the collapse of the very earth itself produces, only a faith which has profoundly convinced itself that the physical frame of things is a mere scaffolding, by the lines of which the spiritual dwelling of man has been fashioned, remains at all. Positivism itself, with its hierarchy of the sciences, all of them resting on the material life as the substratum of everything, would obviously disappear in a moment along with the menace to that physical foundation on which it bases its whole system.

It is curious to think what such races as the Teutonic would become under the influence of frequent earthquakes. Their "solidity" of character, as it is called, largely consists in the confidence they feel in the sameness of all Nature's ways; and whether it would survive that confidence, and outlive the constancy on which it was nourished, is very doubtful. An English squire, for instance, whose timber and crops had changed places with the timber and estates of his next neighbor, would certainly not be recognizably an English squire much longer. An English merchant, whose stock of satins or teas had vanished under the establishment of his rival, would find the world so very much out of joint that he himself would probably become an unmeaning phenomenon. It is, indeed, clear that even rare periodical attacks of earthquake would render the existence of a great capital impossible, and the character of an agricultural population quite different, and probably much more capricious than before. And not unreasonably so. Spiritual faith, even if it remain, can not well rule the actions of physical beings in a physical world which has lost all aspects of constancy. Indeed, repeated shocks to the physical basis of things, though they may well test the strength of faith, can not of course be often repeated on this earth of ours without transferring all the characteristic operativeness of faith to a world of another kind. Faith is faith in divine constancy; and the constancy which has ceased to govern our bodies must be discoverable in some other region, not that of our bodies, if faith is to be of use. Morally, then, the only use of earthquakes must be to *test* the growth of a spiritual faith in a world and life beyond the reach of earthquakes. Clearly it can not strengthen or educate such a faith. It can only sift the false faith from the true, and accord to the true its triumph.—*Spectator*.

SKETCH OF JULIUS ADOLPH STÖCKHARDT.

By Professor W. O. ATWATER.

A FEW miles from Dresden, in one of the many picturesque regions of Saxony, cozily stowed away at the confluence of three lovely valleys, lies the little village of Tharandt, known to a few pleasure-seekers as a charming summer resort, and to the world at large as the seat of a famous school of forestry and agriculture. On an eminence overlooking the village, and itself overlooked by the picturesque ruin of what was once a hunting-castle of the princes of Saxony, is the house; in the village below are the school, the laboratory, and the experiment station; and hard by are the experimental garden and fields where the subject of our sketch, Julius Adolph Stöckhardt, lives and labors. For nearly forty years he has been engaged, by researches, by lectures, by writing, and by the publishing of journals, in promoting and popularizing the science of chemistry, especially in its applications to the culture of the soil. In carrying science to the people, and in presenting it in such ways that the most learned can not criticise nor the most ignorant fail to understand, that every one who reads or listens shall wish to read or listen more, and that the facts when comprehended may be successfully and profitably applied to practice, few living men are his peers. And, as an author as well as interpreter of researches, Stöckhardt ranks among the ablest of the early leaders in this, the golden age of agricultural chemistry.

He was born at Röhrsdorf, near Meissen, in Saxony, January 4, 1809. After receiving a classical education, he studied pharmacy and the natural sciences for several years, and was graduated in 1833 as an apothecary of the first class. In 1834 he traveled in Belgium, England, and France, then devoted himself to pharmaceutical study and research, and in 1838 received the degree of Ph. D. from the University of Leipsic. He then entered upon the teaching of natural science in Dresden, and afterward in the technological school at Chemnitz, and was also appointed inspector of apothecaries. His rare talent for presenting scientific knowledge of matters usually obscure was soon recognized by both students and citizens, and the remarkable power of critical observation displayed in his writings ("Untersuchung der Zwickauer Steinkohle," 1840; "Ueber Erkennung und Anwendung der Giftfarbe," 1844, etc.) was the occasion of almost innumerable applications for the investigation of commercial problems, and demands for his opinion upon scientific and legal questions. In 1843 he traveled in Belgium and France to perfect himself in technological science. In 1846 he published his "Schule der Chemie," which in

1861 had reached its twelfth edition; had been translated into eight different languages, and was used by scores of thousands of students the world over. The current American translation of this work, "Stöckhardt's Principles of Chemistry," is very widely and pleasantly known among teachers and students in this country.

In 1844 Stöckhardt began a course of popular agricultural lectures before the Chemnitz Agricultural Society. To these lectures may be traced the beginning of the movement which, eight years later, resulted in the establishment at Möckern, Saxony, of the first of the agricultural experiment stations, of which there are now over one hundred in Europe and several in the United States, and from whose work, it may be said without exaggeration, has emanated a great part—perhaps the greater part—of our accurate knowledge of the principles of chemistry and physiology that underlie the right practice of agriculture. On the occasion of the celebration, in 1877, of the twenty-fifth anniversary of the founding of the Möckern Station, three albums, with photographs of the directors of the experiments at that time established, were provided: one for the parent station at Möckern, one for Professor von Wolff, its first director; and one for Professor Stöckhardt in consideration of his services in founding and promoting that and other stations.

From 1846 to 1849 Stöckhardt was editor of the "Polytechnisches Centralblatt," and from 1850 to 1855 of the "Zeitschrift für deutsche Landwirthe." In 1848 he was appointed Professor of Agricultural Chemistry in the Royal Academy at Tharandt, where a new chair had been founded purposely for him, and where he has since remained. Since then, extending his idea of popular agricultural instruction, he has given plain conversational lectures to farmers' clubs and societies in Saxony and other parts of Germany, explaining the improvement in agriculture which chemical science has shown to be desirable, and illustrating them with experiments where practicable. The more important of these lectures have been published with the title "Chemische Feldpredigten" ("Chemical Field-Sermons"), and have been translated into several languages. In 1855 he established at Leipsic "Der chemische Ackersmann," a journal which was continued until 1876, when increase of years and cares, and the doing away of its necessity by the establishment, with his aid, of another journal, "Die Landwirthschaftlichen Versuchs-Stationen," occasioned its discontinuance.

But this brief outline of his career gives very little idea of Stöckhardt as a man, an investigator, a teacher, and an expounder of the occult facts of science. To know him in these relations one must see him at his home, among his friends, in his study, his laboratory, his lecture-room, with students and farmers, and must read him in his books.

In appearance and demeanor he is plain and quiet. In social inter-

course he is approachable, kind, ready for a pleasantry, a laugh, or to impart from the great store of his learning whatever the earnest inquirer may need. In the lecture-room his talk is so simple and familiar that the most abstruse principles seem like every-day facts; and his illustrations, drawn from the ordinary and homely experiences of common life, are so clear, pat, and to the point, that one can neither fail to feel their force nor forget their application. With farmers, be they great landholders or humble peasants, his information and explanations are always plain, attractive, practical, and suited to the occasion and the men. And everywhere he is the earnest, laborious, learned, and reverent student, the kindly, faithful instructor, and the worthy man.

Among the especial services Stöckhardt has rendered as teacher and promoter of science is one which, perhaps, is best illustrated in his text-book of chemistry ("Schule der Chemie"), the setting forth of the idea that the right way to teach science is by bringing the student into direct contact with nature, by making him an observer, an investigator, and thus his own best teacher. In the preface to the twelfth edition of this book, he says:

> Experiments must be the foundation of theory. With them the beginner should learn to observe, reflect, and judge; from them he should himself unfold the general chemical relations and truths; he should himself discover, and in this way by his own efforts, along with manual dexterity, acquire an intellectual possession also. Every experiment and every fact observed therein will thus be to him a conquest, and will incite to new exertion.

Accordingly the book abounds with simple experiments to be made with apparatus which any student may get and handle, and is yet sufficient to illustrate, enforce, and impress the truths that are taught, and, what is better, to enable the learner to find the highest inspiration in working out the truths himself. How useful this system of instruction, as thus set forth by Stöckhardt, has proved, may be inferred from the wide circulation of the book as mentioned above, and the facts that sets of apparatus put up to go with it were sent to all parts of Germany, to England, and to Russia, and that a depot for their sale was established in New York.

Of Stöckhardt's greatest work, the promotion of agricultural science, perhaps the best idea may be got from his "Chemical Field-Sermons," which show his methods of popularizing science, and especially from his journal, "Der chemische Ackersmann," in which both his popular treatises and his scientific investigations have been published.

As a discoverer, Stöckhardt, though well known, is outranked by other agricultural chemists of his time. Liebig, the father of agricultural chemistry, Wolff, Henneberg, Knop, Nobbe, Stohmann, Kühn, and others in Germany, Boussingault in France, and Lawes and Gil-

bert in England, have each, perhaps, given the world more of new truth than he. Stöckhardt's chief labor has been to teach, to popularize, to encourage, and thus to promote science, and, withal, to help in its application to practical life. In this great work of mediating between science and the people for whose benefit science is, among those who have done most for agriculture, no man, except, perhaps, Justus Liebig, excels Julius Stöckhardt.

An inkling of the spirit in which Stöckhardt's labors for agriculture has been performed he has himself given us, perhaps unwittingly, in the illustration on the cover of his journal, "Der chemische Ackersmann" ("The Chemical Husbandman"). In the center is a rural scene. In the foreground, cattle and sheep are feeding in the comfort of a peaceful autumn day. Farther away, a reaper is laying down his sickle by the waving grain to follow the heavy load that is trundling homeward from the field. In another field a plowman has left his plow in the furrow, while he and his tired horses are enjoying a brief period of rest. Close by him are the bags of guano and bone-dust to replace the precious ingredients of plant-food that have been carried away with the harvest. Beyond is the little village, with its steep-roofed cottages, and the village church surrounded by shade-trees and surmounted by the tower whose bell calls the inhabitants to morning work, to vesper rest, and to Sabbath worship. Directly in front the ground has been cut away, and reveals, in the deep recesses toward which the roots of trees and herbs are seen to penetrate, a strange laboratory where imps and kobolds are busy with furnace and crucible, retort and mortar, test-tube and balance, as it were, working over the materials and concocting the compounds that are to be gathered up by the plants, and make the fruit to reward the tiller of the soil. Between this occult laboratory and the farm-work that is going on above are the words "*Praxis mit Wissenschaft*" ("Practice with science"). But this scene and motto are not all of the picture, nor do they typify the whole of the spirit of Stöckhardt's life and work. Above are clouds with sunbeams streaming brightly through them upon the earth below, and on them is written, "*An Gottes Segen ist Alles gelegen*" ("On God's blessing all depends").

EDITOR'S TABLE.

THE BUFFALO FIELD CLUB.

THERE is urgent need for more general and efficient association for popular scientific improvement. In politics, in religion, in philanthropy, in reform, and in the original extension of science, the key of influence and the secret of success are coöperation; and this is the agency to which we must look for the popular cultivation of science. The best form of associative action for the promotion of self-education in science is, undoubtedly, the field club, and we are gratified to observe that these excellent organizations are multiplying and doing admirable work. We called attention some months since to the proceedings of the Ottawa Club, and are glad now to be able to report the successful organization of a similar club in Buffalo. It is an outgrowth of the botany and geology classes in the Central High School of that city. These classes have for several years made excursions into the country surrounding Buffalo, under the direction of their able instructor, Professor Charles Linden. The working Field Club was organized in the spring of 1880, with over forty members, and proved successful from the beginning. Professor Linden, the director, is an ardent student and a skillful instructor, and seems to have imbued the members with much of his own enthusiasm for science. The field meetings have been attended on all occasions by a majority of the members. In order to systematize their work, the club is organized into sections in botany, geology, and entomology, and they are now busy in providing cases to arrange and preserve whatever has been collected in the field. Several members have nearly complete collections of the local flora and of geological specimens representing the formations of the vicinity; the entomological branch, which begins work this spring under the direction of Professor Kellicott, of the State Normal School, will no doubt make rapid progress during the coming season and contribute to the increasing success of the club.

Experience has shown that these organizations are only too often ephemeral, and are generally weakened by the prolonged interruption of winter when the excitement passes off, and they need to be freshly stimulated every spring. But there is interesting winter work as well as summer work in science. The Buffalo club has therefore held its meetings all along during the winter in the spacious library of the Society of Natural Sciences. At these semi-monthly meetings papers have been read before the club, followed by their discussion, and an exhibition of specimens necessary to illustrate all the main points upon which beginners are in relative ignorance. When needed, the calcium light and screen have been used to enhance the interest of illustration. The meetings have been well attended by the members, their friends, and local scientists; they have been profitable for instruction, and have kept up an unbroken solicitude for the success of the association.

The twelve papers read at the semi-monthly meetings in the past season were published in the Buffalo "Daily Courier," and were well worthy of being laid before the public. We have been favored with the reports, and have read them all with interest. They are, of course, not of equal merit, nor equally relevant to the strict objects of the club; but, as a whole and as a first

trial, they are admirable. Perhaps the best of the essays are those on "The Gorge of the Niagara," "Alaska," "The Catskill Mountains," "Coal," and "The Tulip-Tree." As the club grows older, the thought of its members will no doubt be more concentrated upon objects within their immediate field of observation, and these will become the subjects of exposition at the winter meetings. It would be well, indeed, if members would take up lines of observation to be pursued during the summer, with special reference to their discussion at the winter gatherings of the club. By taking notes and reading up on the subject chosen, and doing the literary part at convenient intervals, the work would be deliberately and carefully done, and, while the student carried on his own self-instruction, the club would be a gainer by improving the standard of its winter performances.

AGNOSTICISM AT HARVARD.

The students of Harvard University have been canvassed to ascertain their religious opinions. It has been suspected that this institution, so long the headquarters of Unitarian liberalism, has become pervaded by atheism and agnosticism. But it is now found that the believers in these doctrines are virtually nowhere in this great establishment, and that in fact it is drifting away from rationalistic Unitarianism in the direction of pronounced orthodoxy.

There is a great propensity in this country to count up and see who is ahead. Next to the prime national question, "How many dollars?" the American soul yearns to know "How many votes?" Wherever two or three are gathered together, just before election, they are sure to count noses on the nominations. That there should also be a curiosity to know who is losing, who is gaining, and who leads, in the sphere of religious rivalry, is not surprising, for with our people, next after money-getting and politics, sectarian concernments have the most urgent claims. So the Harvard students were questioned as to their spiritual preferences, with the following results: "College and Law School, 972 men; agnostics, 26; atheists, 7; Baptists, 42; Chinese, 1; Christians, 2; Dutch Reformers, 2; Episcopalians, 275; Hebrews, 10; Lutheran, 1; Methodists, 16; non-sectarian, 97; orthodox Congregational, 173; Presbyterians, 27; Quakers, 2; Roman Catholics, 33; Swedenborgians, 20; Unitarians, 214; Universalists, 18; not seen, 6." There has been a great deal of comment and no little congratulation on these unexpected results, but there is one aspect of the matter that we have not seen noticed.

From the point of view of agnosticism there are but two parties in the college, the 26 adherents to that view, and the 940 who do not accept it. The agnostic ground is that religion, in so far as it is supernatural, transcends human intelligence, so that man can really *know* nothing beyond the phenomenal and the finite. He may imagine much, and believe much, and fancy that he knows, but strictly tested it turns out that his conjectures are not knowledge in the true and proper sense. The position of the agnostic, in short, in regard to other worlds or spheres of existence beyond time, space, and the course of nature, is briefly this: "I know nothing and you know nothing, we neither of us can know anything, and we had better modestly confine our thoughts to the universe which we can know."

Now, as there are only 26 that take this ground, it is only fair to suppose that the other 940 take other and opposite ground; that is, they claim to *know* in regard to the religious matters of which they profess belief—claim, indeed, that their religious knowledge is the most clear and certain of all their knowledge.

The Harvard agnostic replies: "The condition and course of things in our

university do not look like it. Let us test your claim by reference to that religious doctrine which is here regarded as of leading importance. The lowest and most rudimentary form of intelligence undoubtedly relates to numbers. No human beings have ever been found so incapable that they could not count a little, if no more than three or four fingers. At the very dawn of intelligence there must arise a perception of the difference between one object and two or three objects. Knowledge may be said to begin here, and, as it agrees with all experience, it is beyond all other knowledge exact, fundamental, and sure. Now, when you undertake to rise above nature and experience, and pass into the realm beyond, what success have you in the application of your primary numerical ideas? Is the infinite object of worship one, two, three, or twenty? Our students are divided over the question; and the fluctuations that are observed in regard to it do not favor the notion that it rests on real knowledge. The mass of our students are not agnostics. They say they know. But, while 214 of them declare that the Divine Being is a unit, 589 of the rest deny this simple proposition, and say that the Divine Being is three or something like it. Since the third century the Church has been quarreling over the application of the most elementary arithmetic to the object of divine worship, and the swaying of opinion now indicated in Harvard University shows that the question is just as unsettled as ever. But if men can not agree in applying the very first and simplest steps of numeration in the transcendental sphere, can they be said to have any real 'knowledge' of it, and how can they succeed better in the application of higher ideas?"

But our Harvard agnostic pushes the case still further. He can say: "We have among us 275 Episcopalians, who, with the other orthodox students, make up 589 professed Trinitarians. They are not agnostics, because they 'know' about this matter; and they are not Unitarians, because they are certain that hypothesis implies a false application of primary arithmetic in the premises. They reject the idea of unity applied to the Deity as false, and condemn it as wicked, and maintain that the true hypothesis is that of tri-personality, or of three Divine persons in the Godhead. But when any one of the '589' is pushed a little to explain himself, and make his alleged 'knowledge' clear, he says, 'Forbear! it is a great mystery, above poor human reason,' and that we are not required to understand it. But that is rank agnosticism! A mystery is simply that which can not be known. So our Trinitarians, who begin by declaring their 'knowledge' of the Divine nature, when cross-questioned, take a ready refuge in the unknowable."

ANOTHER STEP IN EDUCATIONAL PROGRESS.

The great movement of the century to modernize education, and make it conform to the progress of knowledge, is most conspicuously illustrated in England. An old, vigorous, advancing nation, leading in the multifarious work of civilization, and at the same time dominated by conservative habits, and maintaining two ancient, rich, and powerful universities, rooted in the most venerable traditions, England has been well situated for the display of those important changes in which educational progress consists. The tendency of the old universities was to check the growth of thought by a slavish devotion to the learning of antiquity. The spirit of the modern study of nature penetrated them but slowly. Bacon protested against scholastic verbalism, and called men back from the study of words to the study of things. The progress was outside of England's great seats of learning; and, when it had become palpable that they were behind the age and

would not do the work demanded, other universities had to be established more in harmony with the state of knowledge. Various institutions were organized, notably the University of London, which accepted more modern standards of scholarship, and gradually recognized the claims of science as a means of education and a basis of university honors. The conflict between ancient and modern studies has continued and is still rife, but there is no doubt as to how the battle is going. We gave an account not long ago of the newly-organized Mason College, in which the comprehensive educational scheme is based upon science, and the old learning is passed by. We observe that another important step is taken in the same direction by the reorganization of Owens College, which is now known as Victoria University. The students of this college have hitherto mostly taken their degrees at the London University. But the right to confer degrees is now granted to the new university, and in drawing up their plans of study the governing body have been guided by the most liberal and enlightened views of education. They have openly repudiated the old superstition that all minds are alike and ought to pursue the same studies, and they proceed, in the language of the Vice-Chancellor, Dr. Greenwood, "upon the fundamental notion that a man of capacity ought to be encouraged to devote himself with a certain amount of concentration to some particular or definite branch of arts or science study." Of course, students can come to Victoria University and take its best degrees without knowing Latin and Greek. There are various courses, and the standard of attainment is to be high and thorough, but Latin and Greek are no longer indispensable to the acquisition of university honors. We have been a long time arriving at the very common-sense view expressed by Mr. Jacob Bright in a discussion on the policy of the university in respect to classics, that "it seemed to him extraordinary if the whole field of science and learning of various kinds apart from Latin and Greek were not enough to form the basis of a sound education."

HELMHOLTZ'S FARADAY LECTURE.

On Tuesday evening, April 5th, Professor Helmholtz, of the University of Berlin, gave the Faraday Lecture before the Chemical Society at the Royal Institution. As might have been expected, he was greeted by a distinguished audience. Professor Roscoe presided, and, before introducing the eminent German physicist, presented him with the Faraday Medal. The address, notes of which were furnished by Professor Helmholtz to the London press, is reproduced in our pages, and will be carefully read by all interested in chemical physics. It is, perhaps, the most weighty and significant tribute to the genius of Faraday that has yet been made; and at the same time it is itself no slight contribution to physico-chemical theory. It was stated that Faraday, although not a mathematician, had anticipated with great sagacity the results of electro-chemical research by the trained mathematicians of the present generation. Professor Helmholtz's original speculations were thus referred to by Dr. Roscoe: "Upon Faraday's well-known law of electrolysis he has founded a new electro-chemical theory which reveals to us chemists conclusions of the utmost importance. He tells us, as the result of the application of the modern theory of electricity to Faraday's great experimental law, that the atom of every chemical element is always united with a definite, unvarying quantity of electricity. Moreover—and this is most important—that this definite amount of electricity attached to each atom stands in close connection with the combining power of the atom which modern chemistry terms quantivalence. For, if the

amount of electricity belonging to the monad atom be taken as a unit, then that of the dyad atom is two, of the triad atom, three, and so on. Hence, then, thanks first to Faraday and now to Helmholtz, chemists have now a new and unlooked-for confirmation of one of their most important doctrines from the science of electricity."

LITERARY NOTICES.

Popular Lectures on Scientific Subjects. By H. Helmholtz. Translated by E. Atkinson, Ph. D. Second Series. New York: D. Appleton & Co. Pp. 265. Price, $1.50.

The first series of Helmholtz's lectures met with the success which has induced Professor Atkinson to translate an additional volume of them. It is gratifying to know that the translator feels himself justified in this, as it shows a growing popular appreciation of solid intellectual work in science. The contents of this volume are considerably varied, and represent the action of Helmholtz's mind upon widely different subjects. The first paper is an *in memoriam* address on Professor Gustave Magnus, who died in 1869. The essay is not a mere biographical notice or an ordinary eulogy, but is rather an analysis of the character and the scientific labors of Magnus in connection with the state of knowledge and circumstances of his time, so that the paper becomes in some respects an interesting portion of scientific history.

The second paper is "On the Origin and Significance of Geometrical Axioms," and it was a lecture delivered in Heidelberg in 1870. This discussion is not child's play, but many will be attracted to master it because it breaks into the field of speculation with regard to the different dimensions of space.

Artists will be interested in the abstracts of five lectures "On the Relation of Optics to Painting," which were delivered in Cologne, Berlin, and Bonn. After the introductory he takes up successively the subjects, form, shade, color, and harmony of color. His point of view is neither that of the practical artist nor of the student of pictures and schools of painting, but it is that of the physiological optician who is master of a subject. He shows in various ways how a knowledge of the mode of perception of the organ of vision may be of importance to the artist.

Perhaps the most striking of all the papers is the lecture "On the Origin of the Planetary System." So much is said about the nebular hypothesis of Kant and Laplace in these evolutionary times, that many will be glad to see the subject summed up within a moderate compass, and by an authoritative hand. No man is better prepared by his broad scientific erudition and his thorough mastery of mathematical and experimental physics than Professor Helmholtz to report on the present state of knowledge regarding the origin of the planetary system. But it was very far from the author's intention to make a mere popular statement of what former inquirers have arrived at. As one of the founders of the doctrine of the conservation of forces, he may be said to have been an original contributor to the nebular theory; and he is very pointed in his remarks on the grave scientific significance of the inquiry. He says, "Science is not only entitled, but is indeed beholden, to make such an investigation. For her it is a definite and important question—the question, namely, as to the existence of limits to the validity of the laws of nature, which rule all that now surrounds us; the question whether they have always held in the past, and whether they will always hold in the future; or whether, on the supposition of an everlasting uniformity of natural laws, our conclusions from present circumstances as to the past, and as to the future, imperatively lead to an impossible state of things; that is, to the necessity of an infraction of natural laws, of a beginning which could not have been due to processes known to us. Hence, to begin such an investigation as to the possible or probable primeval history of our present world, is considered as a question of science—no idle speculation, but a question as to the limits of its methods, and as to the extent to which existing laws are valid."

Professor Helmholtz is of opinion that our planetary system must sooner or later

come to an end by the exhaustion of its forces. The sun must ultimately "run down" like a clock. He thinks that the existing stock of power available for the maintenance of life may last some seventeen million years, but that it must at length be spent. He thus philosophizes, in conclusion, over the phenomena of the final extinction of life:

However this may be, that which most arouses our moral feelings at the thought of a future (though possibly very remote) cessation of all living creation on the earth is, more particularly, the question whether all this life is not an aimless sport, which will ultimately fall a prey to destruction by brute force? Under the light of Darwin's great thought we begin to see that not only pleasure and joy, but also pain, struggle, and death, are the powerful means by which Nature has built up her finer and more perfect forms of life. And we men know more particularly that in our intelligence, our civic order, and our morality, we are living on the inheritance which our forefathers have gained for us, and that which we acquire in the same way will in like manner ennoble the life of our posterity. Thus the individual, who works for the ideal objects of humanity, even if in a modest position and in a limited sphere of activity, may bear without fear the thought that the thread of his own consciousness will one day break. But even men of such free and large order of minds as Lessing and David Strauss could not reconcile themselves to the thought of a final destruction of the living race, and with it of all the fruits of all past generations.

As yet we know of no fact, which can be established by scientific abservation, which would show that the finer and complex forms of vital motion could exist otherwise than in the dense material of organic life; that it can propagate itself as the sound movement of a string can leave its originally narrow and fixed home, and diffuse itself in the air, keeping all the time its pitch, and the most delicate shade of its color-tint; and that, when it meets another string attuned to it, starts this again or excites a flame ready to sing to the same tone. The flame even, which, of all processes in animate nature, is the closest type of life, may become extinct, but the heat which it produces continues to exist, indestructible, imperishable, as an invisible motion, now agitating the molecules of ponderable matter, and then radiating into boundless space as the vibration of an ether. Even there it retains the characteristic peculiarities of its origin, and it reveals its history to the inquirer who questions it by the spectroscope. United afresh, these rays may ignite a new flame, and thus, as it were, acquire a new bodily existence.

Just as the flame remains the same in appearance and continues to exist with the same form and structure, although it draws every minute fresh combustible vapor and fresh oxygen from the air, into the vortex of its ascending current; and just as the wave goes on in unaltered form, and is yet being reconstructed every moment from fresh particles of water, so also in the living being, it is not the definite mass of substance, which now constitutes the body, to which the continuance of the individual is attached. For the material of the body, like that of the flame, is subject to continuous and comparatively rapid change—a change the more rapid, the livelier the activity of the organs in question. Some constituents are renewed from day to day, some from month to month, and others only after years. That which continues to exist as a particular individual is like the flame and the wave—only the form of motion which continually attracts fresh matter into its vortex and expels the old. The observer with a deaf ear only recognizes the vibration of sound as long as it is visible and can be felt, bound up with heavy matter. Are our senses, in reference to life, like the deaf ear in this respect?

THE HUMAN BODY: An Account of its Structure and Activities, and the Conditions of its Healthy Working. By H. NEWELL MARTIN, D. S. C., M. A., M. B., Professor of Biology in the Johns Hopkins University. New York: Henry Holt & Co. 1881. Pp. 655. Price, $2.75.

THIS work is a contribution to the American "Science Series" of college text-books, and is one of the best of those excellent publications that has yet appeared. Dr. Martin's task in its preparation has not been a light one; for, although he has had the most interesting of all subjects to deal with, and is herein specially fortunate, yet, on the other hand, he has had to compete in the most thoroughly cultivated field of our whole scientific literature. There are many physiological text-books of all grades, and among them are some of the best scientific manuals to be anywhere found. A new work must therefore be of exceptional excellence if it aspires to become a standard on this subject in the higher education.

We have looked over "The Human Body" carefully, and have been interested throughout. The descriptive and explanatory part is remarkably clear, and the accompanying illustrations are abundant and of a superior quality. The book has, moreover, something of a freshness and originality which seemed to be due to the breadth of Dr. Martin's preparation as a biologist. One of the difficulties, indeed, with our physiological text-books is, that they have been too generally the work of physiologi-

cal specialists and exclusive students of the human body. Human physiology of some sort is as old as the practice of medicine, but it became a new science under the influence of modern biology. The human body is only to be understood in connection with the general system of life in nature, and, as this subject has recently been greatly developed, its results should contribute much interesting interpretation to human physiology. Dr. Martin, we think, has written his work from this point of view, and that it may be taken as embodying all the latest assured advances of science in their bearing upon his subject. But, as there is no sharp boundary where accredited science stops, the author, in posting up his work, necessarily encountered the perplexity of dealing with facts and principles not yet settled, for physiology is still an actively progressive science. Dr. Martin does not avoid "disputed matters," but simply aims to do justice to the present state of his subject. He says in his preface: "This was deliberately done, as the result of an experience in teaching physiology, which now extends over more than ten years. It would have been comparatively easy to slip over things still uncertain, and subjects as yet uninvestigated, and to represent our knowledge of the workings of the animal body as neatly rounded off at all its contours, and complete in all its details—*totus, teres, et rotundis*. But, by so doing, no adequate idea of the present state of physiological science would have been conveyed; in many directions it is much further traveled and more completely known than in others; and, as ever, exactly the most interesting points are those which lie on the boundary between what we know and what we hope to know. In gross anatomy there are now but few points calling for a suspension of judgment; with respect to microscopic anatomy there are more; but a treatise on physiology which would pass by, unmentioned, all things not known but sought, would convey an utterly unfaithful and untrue idea. Physiology has not finished its course; it is not cut and dried, and ready to be laid aside for reference like a specimen in an herbarium, but is comparable rather to a living, growing plant, with some stout and useful branches well raised into the light, others but part-grown, and many still represented by unfolded buds."

We have no space to go into the method or classification of Dr. Martin's work, which seems to be lucid and convenient, while the share given to the leading subjects is well proportioned to their importance.

In one respect this manual is better than we expected to find it: it is more thoroughly practical than we were prepared to expect from an experimental biologist, and such a devotee of original scientific study as Dr. Martin is well known to be. We anticipated a valuable and trustworthy scientific treatise, but we are glad to see that the science is constantly and effectively applied to the hygienic art. The application of physiological principles for the preservation of health, the care of the body, and the improvement of the conditions of life, are copiously interspersed through the text, and they will have the effect both of increasing the student's interest in the study and of securing the first object of all education—the acquisition of knowledge indispensable to self-preservation.

Victor Hugo: His Life and Works. From the French of Alfred Barbou. By Frances A. Shaw. Chicago: S. C. Griggs & Co. Pp. 207. Price, $1.

The life of a man who has acquired such a hold upon a nation as Victor Hugo has gained upon the French people can not fail to be full of interest and instruction, and well deserves to be written. The great French poet and patriot has found a competent and appreciative biographer in M. Barbou, who seems to be one of his most enthusiastic admirers, and has associated with him intimately.

The Telescope: The Principles involved in the Construction of Refracting and Reflecting Telescopes. By Thomas Nolan, B. S. Reprinted from "Van Nostrand's Magazine." New York: D. Van Nostrand. Pp. 75. Price, 50 cents.

This little book presents a brief exposition of the optical principles of lenses and mirrors, and their application to the construction of refracting and reflecting telescopes, illustrated by several figures and plates.

Sight, an Exposition of the Principles of Monocular and Binocular Vision. By Joseph Le Conte, LL. D. With numerous Illustrations. Pp. 275. D. Appleton & Co. International Scientific Series, No. XXII. Price, $1.50.

Dr. Le Conte has for many years made the eye a subject of special study, from the point of view assumed in this book. And this is the way this wonderful organ will in future have to be studied. Its interest as an object of investigation is inexhaustible. Its mechanism and action are roughly explained in every physiology; but, to state all that is known about it, in its several aspects in health and disease, would require whole libraries. Helmholtz has made a large and a profound book on physiological optics, devoted to an elucidation of the relations of light to the visual organism, while the psychological relations of the organ of vision have yet to be explored. The eye is, therefore, a subject so complex, obscure, and extensive, that it must in future be approached on different sides by separate investigators. In taking up the eye with a view of explaining the mechanism and process of sight as single and double, our author declares that he does not know the existence of "any work covering the same ground in the English language." He, therefore, claims that it meets a real want, and fills a real gap in scientific literature.

In regard to its form, Dr. Le Conte says: "I have tried to make a book that will be intelligible and interesting to the thoughtful general reader, and at the same time profitable to even the most advanced specialist in this department." It must be admitted that that the author has fairly attained to his ideal. His explanations are so clear, and his facts and principles so interesting, that they will be sure to engage the attention of ordinary readers, while at the same time he gradually passes to the consideration of questions and the presentation of views that will appeal to instructed critics as new contributions to the subject.

Another point in regard to this work strikes us as most important. It is largely a book of experiments; the effects discussed and illustrated with the woodcuts are such as can be tested by the reader who will take some pains to practice. This is an important means of education, by which the reader not only learns how to do things, but becomes acquainted with the subject at first hand, and knows what he knows. On this feature of his book, Dr. Le Conte remarks: "As a means of scientific culture, the study of vision seems to me exceptional. It makes use of, and thus connects together, the sciences of physics, physiology, and even psychology. It makes the cultivation of the habit of observation and experiment possible to all; for the greatest variety of experiments may be made without expensive apparatus, or, indeed, apparatus of any kind. And, above all, it compels one to analyze the complex phenomena of sense in his own person, and is thus a truly admirable preparation for the more difficult task of analysis of those still higher and more complex phenomena which are embraced in the science of psychology."

Sketches and Reminiscences of the Radical Club of Chestnut Street, Boston. Edited by Mrs. John T. Sargent. Boston: James R. Osgood & Co. 1880. Pp. 418. Price, $2.

The Radical Club was founded in the spring of 1867, with the purpose of bringing together occasionally a few persons who were known to be daring thinkers on subjects of high import, and of furnishing them "an opportunity for uttering their thought to an audience capable of appreciating its scope, of criticising its worth, and of developing its relations." It was composed of members of all religious denominations, and enjoyed an attendance of two hundred at the closing sessions of 1880. This volume contains about fifty of the essays which were presented at the meetings, with notices of the discussions which followed the reading. The authors, whose names are appended, are, as a rule, men and women known in literature, science, or the forum, whose words never fail to command attention. The subjects of their papers represent a wide range of thought in literature, art, theology, metaphysics, science, and sociology, and are of degrees of practicality of which "Color-blindness" may be taken to represent one extreme and "The Impossible in Mathematics" the other. The reports of the informal discussions are full of conventional life, and are hardly less interesting than the essays.

Our Native Ferns and how to study them, with Synoptical Descriptions of the North American Species. By Lucien M. Underwood, Ph. D. Bloomington, Illinois. Pp. 116. Illustrated. Price, $1.

The development of interest in the study of ferns is illustrated by the works treating of them, or embodying illustrations of them, that have been published in this country during the last four years. Still, they occupy a subordinate place in our botanical manuals, the descriptions of many species are stored away in inaccessible periodicals and rare books, and, till this work appeared, no manual available to students had been issued that classified all our native species, or outlined their morphology and mode of life. Professor Underwood has made, in the little manual before us, a most commendable attempt to fill this gap in botanical literature. The descriptions of genera and species are preceded by chapters describing in an engaging style the haunts, habits, distribution, morphology, fructification, structure, classification, and nomenclature, etc., of ferns, the germination of fern-spores, "How to study Ferns," and "A Little Fern Literature."

Drugs that enslave: The Opium, Morphine, Chloral, and Hasheesh Habits. By H. H. Kane, M. D. Philadelphia: Presley Blakiston. Pp. 224. Price, $1.50.

This book contains a great deal of information on the narcotic habit, its effects, dangers, and treatment, which is derived from the author's special experience as a medical practitioner, from wide acquaintance with the literature of the subject, and from extensive correspondence with medical men, systematically carried on for the elucidation of obscure or undetermined questions. Though the work aims to be a contribution to medical science, and is addressed to the profession, it yet has a general interest, from the prominence given to the growing dangers of narcotic indulgence among nearly all classes of society. Dr. Kane maintains that a great impulse has been given to the illegitimate use of opium by the introduction of the hypodermic syringe for the injection of morphine under the skin into the tissues. The practice with this instrument is but recent. It was introduced into this country from England in 1856, by Dr. Fordyce Barker, and has not only come into universal use by physicians, but it is much and increasingly employed by individuals, who continue the habit as a fascinating indulgence, which was begun by the doctor for the relief of painful disease. The book is full of examples of the distressing evils of narcotic indulgence, and abounds in warnings against its insidious approaches and deadly results.

Reminiscences of Dr. Spurzheim and George Combe. A Review of the Science of Phrenology from the Time of its Discovery by Dr. Gall, to the Time of the Visit of George Combe to the United States, in 1838–'40, with a new Portrait of Spurzheim. By Nahum Capen, LL. D. New York: Fowler & Wells. Pp. 262. Price, $1.50.

The author was a personal friend and confidential assistant of Spurzheim during his visit to the United States, and is thoroughly versed, as an active sympathizer, with the school of thought of which he was a conspicuous representative from the beginning. He has prepared his reminiscences in answer to what he believes to be a general demand, and has incorporated in it many interesting recollections concerning other advocates of the phrenological school, as Drs. Gall, George Combe, and Andrew Combe.

History of the Free-Trade Movement in England. By Augustus Mongredieu. New York: G. P. Putnam's Sons. Pp. 188. Price, 50 cents.

The question naturally occurs to the observer of national progress, who is also a student of political and economical literature, why, when the majority of the scientific writers and thinkers of all nations agree in approving the principles of free trade, statesmen set them at naught, and only one state, England, has yet adopted them and put them in practice; and they may ask further, What conditions have prompted that country to take a different course from its neighbors? This little book undertakes to answer these questions. It does more. Protectionists assert that England has been declining since it adopted free trade. It answers these assertions by

setting forth "the exact truth as embodied in historical and statistical facts of undeniable authenticity."

Is Consumption contagious, and can it be transmitted by Means of Food? By Herbert C. Clapp, A. M., M. D. Boston and Providence: Otis Clapp & Son. 1881. Pp. 178. Price, $1.25.

Considerable evidence is offered in this work tending to show that, "to a certain extent, at least, and under certain conditions, consumption is contagious." This evidence is derived from incidents in the history of the disease, the statements of physicians, and special reports of twenty-five cases. The subjects of contagion in cattle, the possibility of the transmission of tuberculosis by means of food, and the inoculability of tubercle, are also considered.

The Spirit of Education. By M. L'Abbé Amable Béesau. Translated by Mrs. E. M. McCarthy. Syracuse: C. W. Bardeen. Pp. 325. Price, $1.25.

This little work, by a pious French ecclesiastic, is said to have been very popular in his country. Its author is a Catholic priest, and the work is written from the point of view of the system he represents. It is endorsed by high authorities of the Church as a volume to which Catholics may look with confidence. An interesting feature of the book is its numerous extracts from the writings of eminent Catholics in past times on the subject of education. As might be expected, there is very little recognition of science in the work, and no reference to the more urgent of the modern questions that are agitating the public on the subject of education. It might have been written a thousand years ago.

Lectures on Electricity in its Relations to Medicine and Surgery. By A. D. Rockwell, A. M., M. D. New York: William Wood & Co. Pp. 99. Price, $1.

These lectures deal chiefly with the practical points of the subject, and give special consideration to the methods of general faradization and central galvanization—methods already familiar by name to the profession, but which the author thinks might be better understood and appreciated.

The Logic of Christian Evidences. By G. Frederick Wright. Andover: Warren F. Draper. 1880. Pp. 306. Price, $1.50.

In consequence of the constant changes in the condition of the world and the lines of thought, each generation approaches the subject of the evidences of Christianity from a slightly different point of view. Hence a re-presentation of the subject, corresponding with the new conditions, is always in place. The author regards the power of Christianity to adjust itself in form to different degrees of civilization, while its substance remains unchangeable, as in fact one of the evidences; for the power is a consequence of its spiritual nature, and of its independence of transitory phases of intellectual and social development. The aim of this treatise is to bring into view the external and the internal evidences of Christianity as they now stand, and as they appear when compared with the evidences on which the beliefs of science are based.

First German Book, after the Natural or Pestalozzian Method, for Schools and Home Instruction. By James H. Worman, A. M. New York and Chicago: A. S. Barnes & Co. Pp. 63. Price, 35 cents.

This book is intended for beginners wishing to learn the spoken language of Germany, which is taught in it by direct appeal to illustrations of the objects mentioned, and without the use of English. The author has designed in it to present in a few pages all the essentials of German grammar so as to make their mastery easy, and prepare the student, after going through it, to enter upon the study of the more recondite, complicated, and irregular principles of the language.

PUBLICATIONS RECEIVED.

Tom Paine on Trial, and the Infidels in Court. Brooklyn: D. S. Holmes. Pp. 87. Price, 25 cents.

On Statical Electro-Therapeutics, or Treatment of Disease by Franklinism. By W. J. Morton, M. D. New York. 1881. Pp. 28.

Trances and Trancoidal States in the Lower Animals. By George M. Beard, A. M., M. D. 1881. Pp. 17.

Observations on Jupiter. By L. Trouvelot. Pp. 23.

On the Geographical Distribution of the Indigenous Plants of Europe and the Northeast United States. By Joseph F. James. 1881. Pp. 18.

Abstract of Transactions of the Anthropological Society of Washington, D. C., with the Annual Address of the President, for the First Year, ending January 20, 1880, and for the Second Year, ending January 18, 1881. Prepared by J. W. Powell. Washington: National Republican Printing-House. Pp. 150.

Report of the Cruise of the United States Revenue Steamer Corwin in the Arctic Ocean. With Meteorological Abstracts. By Captain C. L. Hooper, U. S. R. M. Washington: Government Printing-Office. 1880. Pp. 74.

A Dictionary of Music and Musicians (A. D. 1450-1881). Edited by George Grove, D. C. L. Part XIII. Planche to Richter. London and New York: Macmillan & Co. Pp. 128. Price, $1.

Quarterly Report of the Chief of the Bureau of Statistics relative to the Imports, Exports, Immigration, and Navigation of the United States for the Three Months ended December 31, 1880. Pp. 130.

On the Variation of the Leaf-Scars of *Lepidodendron Aculeatum* (Sternberg). With Plates. Pp. 16. On the Variations of the Decorticated Leaf-Scars of Certain Sigillariæ. With Plates. Pp. 5. On the Identity of Certain Supposed Species of Sigillaria with Sigillaria Lepidodendrifolia (Brongniart). With Plate. Pp. 5. By Herman L. Fairchild. From the "Annals of the New York Academy of Sciences."

The Nature of Vibration in Extended Media, and the Polarization of Sound. By S. W. Robinson. Philadelphia. 1881. Pp. 12.

Thoughts on Agricultural Education. By E. Lewis Sturtevant, M. D., South Framingham, Massachusetts. 1881. Pp. 19.

The "Spoils" System and Civil-Service Reform in the Custom-House and Post-Office at New York. By Dorman B. Eaton. New York: G. P. Putnam's Sons. Pp. 123. Price, 50 cents.

A Fourth State of Matter. By Alexander E. Outerbridge, Jr. Philadelphia. 1881. Pp. 11.

Notes on North American Microgasters, with Descriptions of New Species. By C. V. Riley, M. A., Ph. D. From the "Transactions of the Academy of Sciences of St. Louis," April 6, 1881. Pp. 20.

The Infidel Pulpit. A Study of Ingersoll. By George Chainey. Boston. Pp. 8. Price, 5 cents.

The Microscope and its Relation to Medicine and Pharmacy. Edited and published by Charles H. Stowell, M. D., and Lousia Reed Stowell, M. S. An Illustrated Bi-monthly Journal. Vol. I, No. 1. Pp. 32. Price $1 a year.

Physiology in Thought, Conduct, and Belief. By Daniel Clark, M. D., Medical Superintendent Asylum for the Insane, Toronto. 1881. Pp. 15.

Rapid Breathing as a Pain-Obtunder in Minor Surgery, Obstetrics, the General Practice of Medicine, and of Dentistry. By W. G. A. Bonwill, D. D. S. Pp. 16.

On the Geology of Florida. By Eugene A. Smith. With a Plate. From the "American Journal of Science," April, 1881. Pp. 17.

The "Journal of Physiology." By Michael Foster, M. D., F. R. S. Vol. III, No. 1, August, 1880; 2, January, 1881, and Supplement. Published in America under the Auspices of the Johns Hopkins University. Pp. 92, 70, 68. Price, $5 a year.

Contributions to the Anatomy of the Milk-Weed Butterfly, *Danais Archippus* (Fabr.). By Edward Burgess, Secretary of the Boston Society of Natural History. With Plates. Boston: Published by the Society. Pp. 16.

"The Magazine of Art." London, Paris, and New York: Cassell, Petter, Galpin & Co. April, 1881. Pp. 34. Price, 35 cents.

Modern Architectural Designs and Details: for Dwellings, Stores, Offices, and Cottages. Part VI. Plates 41 to 48. New York: Bicknell & Comstock. Price, $1.

The Student's Dream. Chicago: Jansen, McClurg & Co. 1881. Pp. 97. Price, $1.

The Dirt-Cure. By T. L. Nichols, M. D. New York: M. L. Holbrook & Co. 1881. Pp. 88. Price, 50 cents.

Imaginary Quantities: Their Geometrical Interpretation. Translated from the French of M. Argand. By Professor A. S. Hardy. New York: D. Van Nostrand. 1881. Pp. 135. Price, 50 cents.

Locke's Conduct of the Understanding. Edited, with Introduction, Notes, etc., by Thomas Fowler, M. A. Oxford: Clarendon Press. 1881. Pp. 136. Price, 50 cents.

Second German Book, after the Natural or Pestalozzian Method. By James H. Worman, A. M. New York: A. S. Barnes & Co. 1881. Pp. 81. Price, 40 cents.

Working Drawings, and how to make and use them. By Lewis M. Haupt. Philadelphia: Joseph M. Stoddard & Co. 1881. Pp. 53. With Thirty Figures.

Pocket Pronunciation-Book. By E. V. De Graff, A. M. Syracuse, New York: C. W. Bardeen. 1881. Pp. 46. Price, 15 cents.

Short History of Education. Being Articles in the ninth edition of the Encyclopædia Britannica. Edited by W. H. Payne, A. M. Syracuse, New York: C. W. Bardeen. 1881. Pp. 105. Price, 50 cents.

Coöperation as a Business. By Charles Barnard. New York: G. P. Putnam's Sons. 1881. Pp. 234. Price, $1.

The School of Life. By William R. Alger. Boston: Roberts Brothers. 1881. Pp. 205. Price, $1.

How to tell the Parts of Speech. By the Rev. Edwin A. Abbott, D. D. American edition, revised and enlarged. By J. G. R. McElroy, A. M. Boston: Roberts Brothers. 1881. Pp. 143. Price, 75 cents.

Report on Foreign Life-Saving Apparatus. By Lieutenant D. A. Lyle. Washington: Government Printing-Office. 1880. Pp. 45. With Nineteen Plates.

Annual Report of the Operations of the United States Life-Saving Service for the Fiscal Year ending June 30, 1880. Washington: Government Printing-Office. 1880. Pp. 391. With Plates.

The Origin of Primitive Superstitions. By Rushton M. Dorman. Philadelphia: J. B. Lippincott & Co. 1881. Pp. 398. Price, $3. Illustrated.

Second Report of the United States Entomological Commission for the Years 1878 and 1879. Relating to the Rocky Mountain Locust and the Western Cricket. Washington: Government Printing-Office. 1880. Pp. 424. With Map and Illustrations.

POPULAR MISCELLANY.

Diseases and the Weather.—A paper read by Dr. Henry B. Baker, Secretary of the Michigan State Board of Health, before the Sanitary Convention of that State, furnishes some interesting facts concerning the relation of meteorological conditions and particular diseases. Meteorological reports are received from about thirty observers in different parts of the State, who record the

facts of the state of the weather three times a day, and reports of health are received regularly. The reports, as a whole, show how certain diseases vary with the season, and indicate that relations exist, for instance, between the great heat of summer and the amount of sickness from diarrhœa, cholera-morbus, cholera-infantum, etc., and between the cold, dry air in winter and spring and the increase of sickness from pneumonia and similar diseases, which nearly disappear during the warm months. In several years the sickness from pneumonia increased slightly in September, decreased slightly in October, about the time of the Indian summer, and then gradually rose as cold weather set in. When the facts are represented in diagrams, a correspondence appears to be shown between the changes in certain features of the weather and the progress of particular diseases. Thus, the line representing the amount of ozone at night for 1879 nearly agrees with the line representing the prevalence of pneumonia. The bronchitis line is nearly parallel with these, while the lines representing zymotic diseases run in an opposite direction. It is unsafe, however, to lay too much stress on these coincidences, for it is not probable that the amount of ozone was accurately measured. Intermittent fever was at its highest from July to September, remittent fever in August, typho-malarial fever in September, typhoid fever in November, and cerebro-spinal meningitis was irregular, prevailing most from January to March.

Skull-Worship.—"Skull-Worship in the Pacific Ocean" was the title of an address recently made by Herr J. D. C. Schmeltz before a scientific society in Hamburg. The Museum Godefroy in Hamburg has several skulls which have been adorned with stripes over the eyebrows; on some a triangle has been traced in red, from the apex of which another red stripe has been drawn down the nose, with black stripes on either side of it. In other specimens a red line has also been drawn from the apex of the triangle to the roof of the skull, ending there in a spiral on either side. It was already known that the under jaws, if not the whole skulls, of dead relatives were often peculiarly adorned and highly honored in New Guinea. Herr Schmeltz, observing similarly painted skulls in the New Britain Islands, has concluded that a like *cultus* exists there. Herr Kleinschmidt, of the Museum Godefroy, relates that at stated times a kind of priestly person, called at Pall-Pall the Duk-Duk, or religion-man, collects the skulls of the dead and commits them to the care of their relatives; and he has sent to the museum a skull from there, in which the fleshy parts are represented by plaster and the eyes by a snail-shell, and the whole is painted. On one of the New Hebrides Islands whole skeletons of deceased persons have been exhumed, endowed with a flesh prepared from vegetable matters, and installed in the temples. A traveler on the German man-of-war Ariadne sent the museum at Hamburg a skull from the Island of Isabel (Solomon Islands) which had been browned with smoke, and with it the statement that, "when prominent men, who have distinguished themselves in war or by superior power, die, they enjoy after death a particular reverence, which appears to originate in the belief that the spirit of the dead man passes over to his worshiper and makes him fit for similar deeds. After the body has remained for a half-year in the earth, the grave is opened and the skull taken out. It is then subjected to a course of various processes, especially to a protracted smoking, after which it is deposited in the temple as an object of worship."

Chesapeake Zoölogical Laboratory.—The fourth annual session of the Chesapeake Zoölogical Laboratory of Johns Hopkins University was to begin at Beaufort, North Carolina, May 2d, and will continue till the end of August. Dr. W. K. Brooks, Associate in Biology and Assistant Professor of Comparative Anatomy, has charge as director. The laboratory is designed for advanced students, and for persons who are qualified to carry on original investigations. No definite courses of instruction are given, as the persons who are received as students are presumed to have sufficient knowledge to carry on their studies without such aid. An elementary class will also be conducted in connection with the laboratory, during about six weeks of the summer, at which daily lectures will be given, and ar-

rangements made for systematic work in the laboratory, and a part of the class will be allowed to join each day in the dredging and collecting expeditions. Dr. Brooks will exercise personal supervision of the work of this class, and will give a course of lectures on general zoölogy, but the students will be under the more immediate guidance of Dr. S. F. Clarke, who will lecture daily on the structure and habits of marine animals. Beaufort, on account of its diversified fauna, and of its mild and uniform climate, is described as a desirable place for study during the hot months of summer.

Trees and Lightning.—Professor Colladon, of Geneva, published the conclusion several years ago that, when lightning strikes a tree, it is received on the ends of the branches, which, being excellent conductors, lead it, without suffering disturbance, down to the larger limbs. Thence it descends to the main limbs and the trunk, whose conducting power, intrinsically inferior to that of the smaller and younger shoots of the top, is insufficient to sustain the concentrated force of the currents which have united here from the thousand channels by which they have so far descended. Here, then, generally appear the first marks of the shock, not because the lightning has struck the tree at that place, as might be superficially supposed, but because the conducting powers of the tree begin to fail at this point. This view was satisfactorily confirmed by the effect of the lightning upon a poplar-tree, which was struck at Geneva on the 5th of May, 1880. The young, tender leaves of the main topmost branch of this tree and of the branches immediately below it were torn up into small fragments, which strewed the ground below them, as if they had undergone a violent shock of air, such as would be produced by an explosion of dynamite. Many trees may be compared, in respect to their power to conduct electricity, to structures of wood or masonry, which are well furnished with conductors on their upper part, but with which no conducting connection with the ground is given. If such a building were struck with lightning, its upper part would not be hurt, while its lower part would suffer badly. The danger of being struck by lightning, to which persons standing under a tree are exposed, is thus accounted for. The top of the tree, bristling with conducting twigs, attracts the lightning; the current, meeting with non-conducting obstacles at the trunk, jumps from it to the surrounding bodies, whether they be bushes or men and animals. Of two persons, one standing under the tree, the other sitting among the limbs at the top, the latter would be in a vastly safer position. Birds having nests in trees are rarely struck by lightning, and their nests are hardly ever damaged. Large trees growing near a house will protect it from lightning, provided there is no pond or well or stream beyond the house to attract the current across it. If the water is on the same side of the house as the tree, or the tree is between it and the house, or has a rod attached to it, the protection is almost perfect. When a vineyard is struck by lightning, the leaves over a large circuit will, a few hours or days afterward, appear discolored, showing that the electrical action has taken place in a diffused manner, and not in a concentrated attack. In such cases hundreds or even thousands of vines may be affected, showing palpably that it is the property of lightning to manifest itself upon the whole top of a tree or a plot of vegetation. In his memoir on this subject, M. Colladon mentions a single stroke of lightning which left its traces on more than two thousand things.

Progress of Cremation.—Cremation is growing in favor throughout Europe. The first furnace for the purpose was erected at Milan, in 1875; the second, built at Gotha, in 1878, has been recognized by the authorities of the city, so that there the choice between burial and cremation is free to every citizen. Several societies for the advancement of the rite have been formed, some of them even in states where no preparations have been made for performing it. The International Hygienic Congress which met at Milan in September, 1880, adopted a resolution in favor of compelling the bodies of all animals dying of contagious diseases to be incinerated, and of the provision of facilities for that purpose in every parish. It also appointed a special international

committee to draft and present to the several governments within a year a series of propositions for expediting the adoption of cremation. A third furnace for cremation has been built at Woking, England, but has not been used. The society having charge of it, although it is assured by the Government that the execution of its purposes will not be interfered with by the law, is seeking to obtain an express sanction of them from the Government, with the expectation that a measure recognizing cremations properly performed with an efficient apparatus will impose restrictions against the irregularities of indiscriminate cremations, and against the use of defective apparatus.

Glacial Action in the Yellowstone Valley.—Mr. William H. Holmes has furnished the "American Naturalist," from the unpublished report of the Government survey, an account of the glacial phenomena in the Yellowstone Park, which are manifested in a variety of forms, chiefly in erratic rocks scattered everywhere, and in the glaciation of rocks *in situ* in the narrow gorges. It is not always safe to assume that the presence of a bowlder in a particular spot indicates the former existence of a glacier there, for the rock may have been carried to a considerable distance by a force-torrent or by a gradual, creeping movement caused by the undermining of the soil underneath; nevertheless, we have every reason to believe that glaciers formerly existed in the park on a very extensive scale. Glacial moraines are curiously absent from the region; and the tens of thousands of bowlders that dot both sides of the Yellowstone Valley generally lie on the smooth surface of the flood-planes of the river, or on low ridges of alluvial drift. "The significance of this fact may be that the transporting glaciers existed in the earlier stages of the erosion of the valley, and that the morainal ridges have been destroyed by the river, as it oscillated from side to side in the succeeding stages of its descent from the plateau-level to its present bed. These great bowlders would, in such a case, be the more durable masses of the moraines stranded on the various flood-planes for want of water-power to transport them." In seeking for the source of the granite bowlders, it is observed that they occur to a great extent on the south side of the valley, and at all elevations, while the only bodies of similar rock within the valley are found either on the north side or on the bottom at no considerable elevation above the level of the river. Either, then, the bowlders must have been transported to their present positions before the valley existed, or the ice-streams must have been so deep as to fill the valley to the brim and thus carry and strand them. In the latter case, if the glacier followed the course of the valley, the bowlders must have crossed the whole width of it after the manner of a ferry. "This could really occur only in case there should be such an increase in the masses of ice descending from the highlands to the north as to completely fill the valley, sweep across its course and overspread the broad table-land to the south." This table-land, the park plateau, is wholly volcanic, extends for a hundred miles to the south, and is separated from the base of the granite highlands on the north by the valley of the Yellowstone proper and by the East Fork. A great bowlder more than two thousand cubic feet in size which was noticed near the brink of the cañon, and a mile and a half below the great falls, must have come either from the granite highland north of the valley, in which case it must have crossed the valley of the East Fork and the third cañon, and ascended the river for twenty miles, avoiding Amethyst Mountain and the Washburn range by a circuitous route, or, less probably, from the Gallatin Mountains, also twenty miles away, when it must have had to cross the valley of the Upper Gardiner River and the spurs of the Washburn Mountain. If it be admitted, as all the evidence seems to indicate, that the ice-rivers bringing down the erratic blocks of granite came from the north, "it becomes at once clear that the erosion of the grand cañon has been accomplished since the close of the glacial period, or at least that a second erosion has taken place if a cañon existed prior to the glacial epoch."

Refrigeration and Animal Heat.—Dr. Paul Delmas, of Bordeaux, has published the results of some experiments in refrigerating a healthy person by exposing him, dur-

ing from a quarter of a minute to five minutes, to a bath of water at 50°, in which he took notice of the temperature of the subject during the exposure and every five minutes in succeeding hours. During the application of the cold, while the subject showed every sign of very intense sensations, the temperature of the body hardly varied at all, or, at most, less than half a degree from that recorded in the beginning. It still varies but little after the application is over, if, having been dried and dressed, the subject remains perfectly still; but if he exert himself actively, either immediately or after a time of immobility, so as to bring on the external phenomena of cold reaction, the temperature suddenly falls. The reduction persists for several hours, and is more pronounced as the sensation of heat in the subject is stronger. On the other hand, if chill continue or reappear, the animal temperature either does not fall or begins to rise again. The pulse suddenly becomes very quick at the beginning of the cold application; its velocity diminishes after a few seconds, and by the end of the experiment returns to the original rate, or falls below it. The retardation stops or progresses slowly if the subject keeps quiet, but becomes more pronounced and persistent as he gives signs of energetic reaction and of a general sensation of heat.

The Reality of Hypnotic Phenomena.—The "Lancet" publishes an article of Dr. Charles Richet, considering the reality of the phenomena of hypnotism. It is impossible to fix upon a decisive test in this matter. We know that a fact is scientifically certain when the phenomenon, which is the evidence of it, can be reproduced at will by all persons who will use the same processes, as in the case of any chemical or physical manipulation. The phenomena of hypnotism are uncertain, intangible, and variable; different persons, even though employing identical processes, are liable to obtain very different results. The only absolute sign possible is one's own experience, and that is applicable only to himself. There are, however, certain arguments which bear upon the case with almost, if not quite, the force of a demonstration. First, it is absurd to suppose that all hypnotized persons have simulated sleep. Friends, in whom we have absolute confidence, may be among them; it is not possible to believe that they have conspired all at once to deceive us. Second, a close agreement has prevailed among certain of the phenomena of the manifestations for sixty years. "That would be a very strange simulation to be reproduced so often, in so long a time, with the same appearances—closed eyelids, fibrillar movements in the muscles of the face, hallucinations of vision and hearing, catalepsy, contracture"—and this among persons strangers to each other and who may be wholly ignorant of hypnotism. Third, many of the phenomena can not be simulated without a profound knowledge of anatomy and physiology, which hardly any hypnotics possess. When the nerves of the hypnotized person are pressed, the muscles supplied by them contract. Who among them knows what muscles should act under the influence of a particular nerve? Yet no mistake is made. "With somnambulists one can, by direct incitation, cause contraction of the muscles (rudimentary in man) moving the auricle of the ear. Now, this contraction is impossible in the individual when awake." With a certain hysteric, who came under Dr. Richet's observation, "by opening the right eye aphasia was produced; while, by opening the left eye, no such effect was obtained. Certainly, if this be simulation, one must assume that the patient knows that speech is affected by the left cerebral hemisphere, and that the retina of the right eye is in relation with this hemisphere, while the right hemisphere is useless for speech." The hysterical contractures afford equally convincing evidence. "There is no individual strong enough to preserve voluntarily the contraction of a muscle during a quarter of an hour without one perceiving in it the slightest tendency to weakness or relaxation. Now, somnambulists maintain their contractures for many hours, and on waking they have no recollection of, no fatigue from, this prolonged and improbable effort." Again, insensibility may be feigned; "but how many persons are there who would have the courage to bear, without serious reason, pricks in the face, on the nostrils, or hands; to allow their hair

to be plucked out, and the conjunctiva, the nose, and the ears to be tickled; to have pins thrust into the arms; to drink nauseous liquids; to breathe with delight ammonia or sulphurous acid?" Somnambulists oppose no resistance to tests like these. "Must we suppose that they exhibit heroism (and a very misplaced heroism) or anæsthesia?" It is objected that the phenomena of somnambulism are incompatible with the facts of science. But, if they are themselves facts, they can not be overthrown by *a priori* reasoning. Another objection has been made: that everything observed in hypnotism is inconstant, irregular, mobile, and that the phenomena vary with every observer and with each subject. The same is the case with other psychological phenomena, and the diversities may, in all cases, be perfectly explained by the prodigious complexity of the mind. "We ought to be really struck by the resemblances rather than the differences, for the latter are of small account relatively to what they might be."

Gradual Disappearance of the Larger Animals.—The species among the different classes of animals which exceed their congeners in size are now more than ever threatened with extermination. The progressive diminution in their numbers has been more rapid during the recent geological period because they have had man as their competitor; and the present age may be destined to witness their entire disappearance. In consequence of the new competition opposed by man, more formidable than any other that the large animals have had to meet, many species have already become extinct, and many of those which are still represented among living beings are daily diminishing in numbers. The animals comprising these species, being those which are hunted with profit, or those the destruction of which is important for human security, are for these reasons inevitably the most exposed to be driven from every region in which the privileged being has established his abode. In the struggle which they have to sustain against the new rivalry they labor under the two marked disadvantages, as compared with smaller animals, that they require a more abundant supply of food and that their reproduction is less frequent and more limited, so that the losses they endure are hardly repaired. The smaller species keep up their numbers, and even increase, in consequence of their extreme fertility, in spite of the most persistent efforts of man to exterminate them. The larger animals would be totally destroyed in a very short time if they had to suffer the same proportion of losses. It is hardly rash to assert that the whales, the cachalots, the *Sirenidæ*, the morses, certain species of seals and otaries, the great white bear of the Arctic coasts, and the other bears, the large carnivorous cats (lions, tigers, etc.), the gorillas, the great armadillo, the great ant-eater, the giraffes, the elan, the aurochs, the bison, the elephants, the hippopotamuses, the rhinoceroses, the great kangaroo, the elephantine turtles, the crocodiles, the birds of the ostrich group, the great penguin of the frozen sea, etc., are threatened with the fate that has within a few centuries befallen the enormous epiornis of Madagascar, the gigantic moas of New Zealand, and within less than two centuries the dodo and the giant bird of the Island of Mauritius, the two latter species representing the largest columbid and the tallest waterfowl that have ever existed. The great carnivora are already fast disappearing before the bullets of emulous lion and tiger hunters; the whales and other larger mammalia are becoming scarce. The largest of the deer, the elan, is less widely distributed than formerly; the largest of wild cattle, the aurochs, which formerly ranged over all Europe, is now found only in the forests of Lithuania and Moldavia; the bison no longer covers the prairies with boundless herds; the great armadillo is disappearing from South America, and the great kangaroo from Australia; and the numbers of the other animals we have named are gradually diminishing. It is time for science to be busy in completing the study of these animals before some of their species go to join the ranks of those which are represented only in fossils.—*La Nature.*

Mechanical Vibrations as a Remedy in Neuralgia.—M. Boudet de Paris and Dr. J. Mortimer-Granville have published observations upon the application of mechanical vi-

brations as a remedy for neuralgia. The publication of M. Boudet de Paris was earliest in time; but Dr. Mortimer-Granville has been prosecuting researches on the subject for several years, while he intended to withhold the results from the public until the efficacy of the new remedy could be fully established. The publication of M. Boudet de Paris has, however, made it necessary for him to describe his own views and experiments, so far as he has gone, though he still considers them unperfected. His attention was drawn to the subject by the success of applications of ice in alleviating neuralgic pains in labor. Having persuaded himself that if the nerve affected in such pains could be strongly impressed, so as to change its state of irritation, the pain would cease, he tried the effect of tapping over the fifth nerve in ordinary facial neuralgia. The results were "very remarkable." He then devised an instrument, a *percuteur*, which would give a known number of blows in a second. The operations of this instrument were remarkable, although they are not yet considered decisive as to its efficacy. In numerous instances, pain was arrested by its application, and did not return. When applied over a healthy nerve, which was so situated as to be thrown readily into mechanical vibration, it produced a sensation like that caused by the passage of a weak, interrupted current of electricity, changing, when the action was prolonged, into a sensation of tingling, then of numbness, and finally to some twitching of the superficial muscles. A nervous headache, or *migraine*, could be produced by an application to the frontal ridges or the margins of the orbit. In some instances, when pain existed, the sensation was aggravated by the augmented state of vibration into which the nerve was thrown through the shaking of the adjacent tissues. It is noteworthy that a comparatively high number of vibrations per second seems to relieve a dull, aching, or grinding pain, while an acutely pitched and quick pain is most frequently arrested by a slower movement of the instrument. This is in harmony with the theory that the pain is the result of abnormal nervous vibration, and that the operation of the *percuteur* is to arrest those motions by opposing counter and interfering vibrations to them. M. Boudet de Paris relates in his paper that, by the aid of a large tuning-fork and sounding-board, he caused hemianæsthesia to disappear; provoked contractions in hysterical patients at the Sâlpetrière as rapidly as with the magnet or electricity; and subdued the pains of an ataxic. With a modified apparatus he was able to produce local analgesia, often anæsthesia, in a healthy man, or a sensation of approaching vertigo, with a desire for sleep. An attack of *migraine* could be cut short by the application. Neuralgia, especially of the fifth nerve, disappeared after a few minutes' application of the instrument; but it was more difficult to get good results with the deeper-seated nerves. Both gentlemen suggest that the action of metallo-therapy, or of metallic applications, is best explained on the theory of vibrations.

Some Facts about Explosions.—Mr. Cornelius Walford has lately attempted to collate the statistics of explosions, as a help to ascertaining their causes and the means of avoiding them. A large increase in such disasters, which has been remarked in modern times, is easily accounted for when we remember that we deal with explosive materials and machinery vastly more than our ancestors did. The returns of the deaths from explosions in England and Wales, during twenty-two of the years between 1852 and 1879, give a total of 6,814, or 309 a year, of which 187 a year were ascribed to explosions of fire-damp, 37 to those of boilers, and 70 to those of chemicals, including gunpowder. Assuming, as the insurance companies do, that one hundred persons are hurt by such accidents where one is killed, a proportion which is not confirmed by the figures that follow, we have an annual average of 30,900 persons injured by explosions in England and Wales. No means exist of ascertaining the amount of property destroyed. Explosions of chemicals are increasing in frequency and variety of character as new processes are introduced in the arts. Remarkable instances of these occurred at Gateshead in 1854, when, during a fire, nitrate of soda and sulphur, neither of which would explode alone or in simple combinations, exploded terribly when water was brought to bear

upon them; in the explosion of bisulphide of carbon in a shoddy-oil factory in 1867; and in a celluloid-factory at Newark, New Jersey, in 1879. An explosion, believed to be of carbonic acid, which occurred in a French coal-mine, is supposed to have been caused by the formation, from the decomposition of pyrites, of sulphuric acid, which, finding its way to the limestone, suddenly generated large quantities of gas. M. Kuhlmann has shown that sulphuric acid mixing with ten equivalents of water may cause a very violent explosion. Of 156 colliery explosions, recorded in the United Kingdom during the present reign, the largest numbers occurred in February, March, and December, and the smallest number in May. Help in the study of disasters of this class is expected from meteorological investigations. Dust has recently been found to be a formidable explosive, and is now believed to have nearly as much to do with coal-mine accidents as fire-damp. The charred appearance of the wood-work in coal-mines after explosions is ascribed to the deposition of a crust of scorched or melted coal-dust upon it. The fine dust generated in some of the processes employed in flouring-mills has been recognized lately as a very dangerous source of explosions, and attention has been directed to the contrivance of improvements in machinery to mitigate the perils to which the workers in tens of thousands of mills are exposed from it. The dangers arising from the liability of illuminating-gas to explode are great enough, but they would be much increased if a process should be adopted for depriving the gas of its odor. The explosive properties of gunpowder and petroleum in all the ways in which they are used are familiar enough and dreaded. The frequent damage to powder-mills by lightning may be ascribed not so much to the attractive power of the substances stored in them as to their isolated situation on marsh-lands near rivers. Insurance-tables show that 1,536 explosions of steam-boilers have taken place in the United Kingdom during the present century, killing 2,293 persons and injuring 3,259. In the United States, 1,299 explosions, killing 2,506 persons and injuring 2,612, are recorded as having taken place between October 1, 1867, and January 1, 1880. The largest number of these were in saw, planing, and wood-working mills, the next largest in steam-vessels, and the next largest of railroad locomotives. The greatest number killed and injured were on steam-vessels. The causes of explosions, according to English tables, appear to be about evenly divided between bad design, workmanship, and material, and ignorance or carelessness of attendants. A smaller number were attributed to defects arising in course of use. The most frequent and most destructive explosions in England appear to have been in iron-works and mines.

Earthquakes in England.—The earliest earthquake in England of which a record has been made took place in 1101, when, according to William of Malmesbury, the whole country was terrified "with a horrid spectacle, for all the buildings were lifted up, and then again set down as before." The next was in 1133, when houses were overthrown and flames were said to have issued from rifts in the earth. A third shock occurred in 1185, when, according to Holinshed, "stones that lay couched fast in the earth were removed out of their places, houses were overthrown, and the great church of Lincoln rent from the top downward." An earthquake in 1247, by which much property in London was damaged, was preceded for three months by a suspension of tidal movements on the English coast. On April 6, 1580, two shocks occurred, the second of which caused the church-bells to ring, threw some stones from St. Paul's Cathedral, leveled a part of the Temple Church, caused the death of two worshipers in Christ Church, by the falling of a stone from the roof, and threw a part of the cliff of Dover into the sea. Excitement prevailed for weeks afterward, business was seriously affected, riots were frequent, and prayers were prepared to be offered night and morning for protection against further convulsions. Two undulatory movements of the earth, lasting together about four seconds, took place at noon on September 8, 1692, causing a great panic, but not inflicting very serious damage on property. A slight but evident shock, accompanied with a "great roaring," took plack on February 8, 1750, when bells were rung, "dogs howled, and fish jumped

high out of the water." A month later, the people were awakened between one and two o'clock in the morning by a series of shocks. A frantic terror, causing neglect of domestic concerns, riot, and a suspension of business enterprise, possessed all classes for several weeks afterward. It was heightened by a prediction that a third earthquake would occur in April, and all who could left the city; others spent their nights out of doors. A quack made his fortune during the panic by selling pills which he warranted to be a sure preservative against injury by earthquakes. Only slight shocks have since been felt in the metropolis.

Impure Air and Disease.—Dr. J. Ward, health-officer of an English sanitary district of considerable extent and population, has given in the "Sanitary Record" an account of a large number of instances which have come under his immediate observation, in which impure air, arising either from defective ventilation or noxious surroundings, has appeared to be directly associated with the production of diseases of the lungs and other organs. Of eight fatal cases of pneumonia occurring within a year among children and persons in middle life, in all but one the air was defiled from some neighboring source of filth. In about ninety fatal cases of diseases of the respiratory organs, other than pulmonary consumption, most of which were acute or subacute, undoubted defects of ventilation existed. In some cases there was no fireplace or air exit in the room; in some, such opening, where it had existed, had been closed tight; in some the bed, with many in it, was in a close corner; in others the air was defiled by some neighboring household or farm nuisance. Similar defects were observed in nearly all of thirty cases of disorders of the lungs following measles; in forty cases following whooping-cough—in sixteen of which last, "filth influence from immediately contiguous byre, pig-styes, stable, water-closet, or sewer, was noticed." The sanitary investigation of the interior and surroundings of houses where inflammatory affections of the brain have occurred has forced upon Dr. Ward the conclusion that diseases of this class are also frequently, and, it may be inferred, causatively, associated with similar insanitary conditions. In twenty-eight fatal cases of this nature, seventeen cases of tubercular meningitis, and twenty-two cases of convulsions in children, the air was either confined or polluted. Dr. Ward draws from these observations the obvious lesson that it should be the aim of sanitary administration to secure for each habitable room, especially in the crowded cottages of the poorer classes, some suitable provision for a constant change of air. Particularly should care be taken in fixing the position of the bed so that it shall not be in a close corner remote from the influence of the door, window, and fireplace, but should be near some opening through which a constant circulation may be relied upon. In transforming old houses, the provision of fresh air, now neglected and too often prevented in the arrangement of the partitions, should be carefully looked after—else the sanitary condition of the house may be made worse than it was before.

An Improved Filtering Apparatus.—Some experiments that have lately been made in France on the working of the Farquhar apparatus for filtering sewage have been attended with quite satisfactory results. One of the chief obstacles to the purification of foul waters by filtration has arisen from the accumulation of an impervious, slimy deposit on the matter which prevents the liquid from reaching the filtering surface. The Farquhar apparatus is designed to obviate this difficulty by means of a provision for the continuous removal of the slime. The filter-bed, which may be composed of any suitable material, is contained in a closed cylinder in which is worked a cutter-plate continually scraping off the top of the deposit. The liquid to be filtered is forced in through a hollow in the screw-spindle by which the cutter-plate is worked, direct to the underside of that instrument, where it is uniformly distributed over the surface of the filter-bed. The cutter-plate is caused, by suitable machinery, to revolve during the process of filtration, and may also be made to descend if that is desired. The accumulating deposit is scraped off, and forced up the inclined plane of the knife, as shavings are forced up through a carpenter's plane, to

the upper surface of the cutter-plate. By this operation a new clean surface is constantly produced on the filter-bed, practically starting a new filter, at each revolution of the cutter-plate. A model machine, when tried with common sewer-waters at Asnières, near Paris, having a filter-bed of $9\frac{1}{3}$ inches in diameter, filtered eight litres, or 1·761 gallons, in a minute under a pressure of one atmosphere and a half. In the same proportion the rate of filtration with a bed one foot in diameter would be 3·31 gallons a minute, and with a bed ten feet in diameter 260 gallons a minute, or 374,400 gallons a day of twenty-four hours. Applied to the water-supply of towns, a machine having a filter-bed ten feet in diameter should filter, under a pressure of one atmosphere, 466,560 gallons in twenty-four hours.

Origin of Diphtheria.—The observations of Mr. G. H. Fosbrooke, medical health-officer of Birmingham, England, have led him to form conclusions respecting the etiology of diphtheria which differ in some points from those which have been urged by other authorities. He regards it as a well-established fact, confirmed by his experience, that the disease is more common in rural than in urban districts, and has observed that even when it has prevailed extensively in a rural district, and has thence been conveyed into a neighboring town, it has not spread in the town. In one town of five thousand inhabitants, diphtheria, when it occurred, prevailed concurrently with typhoid fever or scarlatina, giving rise to the suggestion that all those diseases might originate in a common poison. Mr. Fosbrooke does not agree with other authorities as to the conditions of soil most favorable to the propagation of diphtheria. Generally the disease has been thought to flourish most in damp situations and in connection with damp subsoils. All of his attempts to associate its origin and distribution with any peculiar soil or situation have failed, for he has met it both in villages occupying elevated and airy situations and in low places. The most serious epidemics and the larger number of cases of which he has had personal knowledge have appeared on soils that were "rather gravelly and well drained." With one exception, his experience opposes the idea that houses shut in by trees are more liable to harbor the disease than those which are not surrounded by an abundant vegetation. The fluctuations of diphtheria, when it prevails for any considerable length of time, do not appear to be influenced by changes of season or by variations of weather. Meteorological observations, made with reference to this point, differ widely, and furnish no guide to an opinion. The disease is generally found first to break out in October, and to prevail as an epidemic, when it does so prevail, in the winter months, increasing, as is natural with epidemics, during the earlier months of its course, but without regard to the regularity or irregularity of the season.

Anthropology in Russia.—Anthropology has made much progress in Russia. The Imperial Society of the Friends of Natural Science, Anthropology, and Ethnography, founded in 1863, of which Bogdanof is the master-spirit, has done good service in assuming the patronage of investigations among the numerous diverse stocks of whom the Russian nationality is composed, and in encouraging measures to bring the interests of anthropology before the public. The Anthropological Exhibition, which was held at Moscow last summer, had this object prominently in view, and was further intended to promote the establishment of a professorship of anthropology, and of an anthropological museum. The collections exhibited and reported upon embraced skulls, skeletons, relics, prehistoric and modern, and articles of various kinds, illustrating the character, condition, and customs of the ancient and modern inhabitants of the empire. Among the neolithic stone implements from Kazan were hatchets, crossed by a groove in which to fasten the handle, precisely as in the North American hatchets, and arrow-heads, both with and without shafts. Fragments of urns bearing the well-known pack-thread ornament and bronzes of the so-called Tschudic type were shown from the Volga. Filimonof brought from the Caucasus, where he has been digging under the auspices of the society, great bronze whorls, of similar form to those which are met in the Baltic provinces, but

larger, fibulæ, precisely like those of the *terra mare* of Italy, but to which nothing similar has been found between the two places, and Etruscan potteries. These articles are probably of the sixth century B. C., and relics of Italian colonists. A splendidly ornamented bronze hatchet, from the same region, also deserves mention. Filimonof has concluded, from the researches he has made, that the transition from bronze to iron took place in the Caucasus about five hundred years before Christ. Bronze buckles from near Kertch, like those of the Merovingian period in France, were probably Roman. Craniology was fully represented by more than five hundred Kurgan skulls, and by a host of skulls representing about twenty races of Europe and Asia. Among the numerous skeletons were two of Ainos. A skull of the stone age from the government of Vladimir and pieces of other skulls and skeletons found with it are the oldest remains of man yet found in Russia, and the first of the stone age. Professor Inostranzof, of St. Petersburg, has recently found other human remains of that age. The ethnographic department was not so fully represented as the others, but included collections illustrating the various modes of caring for infants, embroideries, articles of household manufacture, models of houses and farm-buildings, musical instruments, hunting, fishing, and farming implements, and rare articles representing the diversified populations of Siberia, the last being contributed by the Imperial Russian Geographical Society of St. Petersburg. This department is richly illustrated in the collection of the Rumyanzof Museum, of Moscow.

The Phæodaria.—Professor Ernst Haeckel, at a recent meeting of the Natural History Society of Jena, read a note on the phæodaria, a new group of marine siliceous rhizopods, rich in specific forms and remarkable in many respects, which have hitherto been included in the typical radiolaria, from which, however, they present considerable points of difference. A new light has been thrown upon these beings by the Challenger Expedition, which, besides discovering forms of typical radiolaria corresponding to two thousand species, brought to light a number of deep-sea phæodaria, hitherto entirely unknown. John Murray, in 1876, described some of the forms of these new species, drawing attention to the extremely delicate and finely fenestrated structure of the large siliceous shells, and to the constant appearance of masses of black-brown pigment which are scattered through the sarcode, outside the central capsule. These animals are usually considerably larger than the other radiolaria, and many of them are visible to the naked eye. They bear a peculiar mass of dark pigment-granules, called pheodium, outside the central capsule, and have, with few exceptions, a well-developed, always extra-capsular, siliceous skeleton, which forms very varied and delicate structures, usually radiating outward in hollow siliceous tubes.

Industrial Accidents, etc.—Mr. T. A. Brocklebank suggests that the amount of sickness and death incurred in industrial operations in England, as a direct result of the conditions under which they are carried on, is a subject that demands investigation. In 1877 he compiled tables for use before the House of Lords, which gave returns of deaths and injuries by boilers in mines, on railways, and at factories, with totals for 1873, 1874, 1875, and 1876, of 107,000 men, women, and children; and he estimates, on the basis of the facts contained in these tables, that 500,000 workmen will be killed during the ten years, 1877 to 1886, as follows: in mines, 300,000; on railways, 70,000; in factories, 180,000. Sir Edward Watkin also has made a statement in the House of Commons to the effect that 100,000 persons are killed annually in industrial occupations in England. Facts are cited to show that the accidents that are reported compose only a part of those which take place, and to make it appear probable that Mr. Brocklebank's estimate is a very moderate one.

Sewage-Farming.—The Royal Agricultural Society has recently awarded two prizes of one hundred pounds sterling each for the best managed sewage-farm, the one utilizing the sewage of not more, the other that of more than twenty thousand people. Nine farmers competed for the two prizes. The judges stated in their report that there was a very considerable difference, both in the

amount of capital engaged upon the several farms, and in the gross returns per acre. The gross returns and the amount of wages paid per acre were greatest in cases where market-gardening was in vogue. It was remarked that a large area of ordinary agricultural land attached to a sewage-farm does not always add to the profit of the undertaking. Statistical tables showing the number of persons living or working on the farms, and the number of children on them, make it appear that the average annual mortality upon them does not exceed three per thousand, and that "sewage-farming is not detrimental to life or health." About one hundred sewage-farms are in operation in England.

Habits of the Green Lizard.—Sarah P. Monks has contributed to "The American Naturalist" an interesting study of the habits of two green lizards, or American chameleons, which she has kept in her rooms. The first, a female, came from South Carolina in November, and was kept in a room warmed with a furnace. It was very lively and ran about a great deal during the winter, but paid no attention to the flies till the warm spring-days came, when it greedily devoured them and eagerly lapped water with its tongue. When a male lizard was put in the cage in May, a curious ceremonial courtship took place between the pair, each animal raising itself to the full extent of its forelegs and bowing its head and the forepart of the body in a regular and dignified manner as if it had a hinged joint at the shoulder. Both lizards would scamper off when they found that their actions were observed: and, if a fly came near them, they would dart after it "like a flash of green light." The changes of color in the creatures were frequent and marked, but the observations upon them were contradictory and unsatisfactory. The changes were different in the two specimens: the same causes did not affect them both alike; and the changes came on without regard to the object on which they were placed, or to the amount of light and darkness. They would become green or light-brown when placed in sunlight, but would also assume the same colors in the darkest room. When disturbed they would sometimes become darker, but at other times would not change. The changes were rapid, taking place in from two to eight minutes; and at one time one of the lizards changed from green to light-brown, then back to green again, in five minutes. They would go to sleep as soon as it became dark, and in the gloom of a storm, and would wake again on the appearance of the sun, although they were not exposed to its direct rays. They assumed various positions in sleeping—sometimes, when it was cool, lying close up under a bit of loose bark, sometimes curled in a corner behind a small jar, sometimes stretched out on a limb or along the twigs. When in a crevice or hole, they took any shape that was convenient, but on sticks and twigs they arranged themselves so as to imitate the general form of the branches. The changes of the skin do not appear to depend upon any particular time or season, but upon the general health and growth of the animal. One of the lizards changed twice in seventeen days, the other only four times in five months. The skin split along the back and the upper sides of the legs, and came off in large fragments. The lizard would seize a bit in his mouth and pull it off as if it were an inverted glove, and would then eat it. The bits of skin that remained around the jaws and eyes seemed to annoy the animal very much. When the tail had been broken off and renewed, as was the case with one of the lizards, the exuviation of that part took place independently of the rest of the body.

The Safe Manufacture of Dynamite.—The French Academy of Sciences has recently awarded a prize of twenty-five hundred francs to Messrs. Boutmy and Foucher for introducing new modes of producing nitro-glycerine in quantity, by means of which the manufacture of dynamite has been rendered much safer than it has heretofore been. The old method, in which fuming nitric acid, or a mixture of that substance and sulphuric acid, was made to act on glycerine, and the mass was suddenly immersed in water, often resulted in the production of enough heat to decompose a part of the nitro-glycerine, and occasion a violent explosion in spite of the best refrigerating processes that could be employed. The principle of the new process consists in

obviating the greater part of the heat by first engaging the glycerine in a combination with sulphuric acid, which forms a sulpho-glyceric acid, and then destroying this compound slowly by means of nitric acid. Two liquors are prepared in advance—a sulpho-glyceric and a sulpho-nitric liquor (the latter with equal weights of sulphuric and nitric acids). These disengage a considerable amount of heat; they are allowed to cool, and are then combined in such proportions that the reaction takes place slowly. In the old method the nitro-glycerine is separated almost instantaneously, and rises in part to the surface, rendering washing difficult; in the new method it forms in about twenty hours, with a regularity which prevents danger, and goes to the bottom of the vessel, so that it can be washed rapidly. In the works of Messrs. Boutmy and Foucher at Vouges, where the new process has been employed, no life has been lost for six years, and the general health has been excellent.

NOTES.

The annual meeting of the National Academy of Sciences was held in Washington, D. C., beginning April 19th, under the presidency of Professor W. B. Rogers, of Boston. The sessions continued through four days, and were marked by the reading of a large number of papers, of general as well as special interest. None of the papers received more attention than that of Professor Bell concerning his later experiments in the production of sound by radiant energy, which we publish. Professor Barker, in his paper on "Incandescent Lighting," also touched a subject which engages general interest. The papers of Professor Pumpelly, on the relation of soils to health, of Professor Morse, on the utilization of the sun's rays in heating and ventilating, and others, show that the Academy does not neglect practical subjects. Mr. W. H. Dall gave an account of the "Land Ice in Kotzebue Sound," of which mention has already been made in the "Monthly"; and Professor T. Sterry Hunt described the "Auriferous Gravels of California." President Garfield visited the Academy, and was warmly welcomed. The meeting was more than ordinarily interesting.

The Boston Society of Natural History announces that a seaside laboratory, capable of accommodating only a limited number of students, will be open under the direction of its curator, Alpheus Hyatt, at Annisquam, near Gloucester, Massachusetts, from June 5th to September 15th. As the purpose is simply to afford opportunities for the study and observation of common types of marine animals under suitable direction and advice, no attempt will be made to give any stated course of instruction or lectures. The work will be adapted to meet the wants of those who have already made a beginning in the study of natural history. The apparatus will consist of the simplest laboratory furniture, collecting instruments, and row-boats, and a yacht for dredging excursions after the latter part of July.

Achille Delesse, an eminent French geologist, died March 24th. He was engaged through most of his life as a mining engineer, and was at one time Professor of Geology and Mineralogy at Besançon, and at another Professor of Agriculture, Drainage, and Irrigation in the École des Mines. He was author of works on some of the mineralogical features of the Vosges, of "Researches on the Origin of the Rocks," geological and hydrological maps of the city of Paris, and the rainfall of Paris, and, in conjunction with MM. Langel and De Lapparent, issued for twenty years the annual "Revue de Géologie." He was for two years President of the Geological Society of France.

"Nature" doubts whether our Fish Commissioners will be able greatly to increase the yield of sea-fish, like shad, herring, and cod. The arguments of Malthus respecting the relations between food-supply and the increase of population are thought in England to be applicable to fish. "Sea-fish, like all other animals," it says, "are undoubtedly increasing in greater proportion than their food; and it is obvious, therefore, that, unless man can increase their food, it is only lost labor to increase their number."

Fanny, a very aged carp in the ponds at Fontainebleau, well known to the people of Paris, has just died. She is said to have been hatched during the reign of King Francis I, and had become very gray.

The sixth session of the Summer School of Biology of the Peabody Academy of Science, Salem, Massachusetts, will commence July 12th, and continue for four weeks. Instruction designed especially for teachers. Further information may be obtained from Professor Edward S. Morse, of Salem.

Mr. William Pearce, of the Clyde shipbuilding firm of John Elder & Co., has stated, in a lecture on recent improvements in marine navigation, that the first steamers of the Cunard Company, in 1840, were under contract to go $8\frac{1}{2}$ knots an hour; were of 740 horse-power; and consumed $4\frac{7}{10}$ pounds

of coal per horse-power. The Persia, built in 1856, had side-lever engines, indicating 3,600 horse power, and consumed 3 $\frac{7}{8}$ pounds of coal per horse-power. The Gallia, built in 1879, was fitted with compound engines of 5,000 horse-power, and sailed with a speed of 15½ knots an hour. The Persia burned 6¼ tons of coal for every ton of cargo it carried; while the Gallia burned less than half a ton, although it carried the cargo 2½ knots an hour faster than the Persia. The Arizona, with 6,000 horse-power, consumed 1¾ pound of coal per indicated horse-power, and carried 3,400 tons of cargo at an average speed of 16¼ knots, burning less than four hundred-weight per ton of cargo at a speed across the Atlantic faster than any previously recorded.

Dr. Hiram A. Cutting, of Vermont, has made a series of examinations into the durability under heat of different kinds of granite, sandstone, limestone, marble, conglomerate, slate, soapstone, and artificial stone. Granite began to yield at a temperature of between 700° and 800°; it became cracked between 800° and 900°; generally cracked between 800° and 950°; and was made worthless by or before reaching a temperature of 1,000°. Sandstones showed a greater power of endurance, massive limestones still greater, and marbles the greatest, while conglomerates seem to have been among the weakest stones. The least absorbent and the most absorbent of the granites were equally the granites most destructible by heat.

The annual meeting of the Society for the Promotion of Agricultural Science will be held at Cincinnati, August 16th, the day before the meeting of the American Association for the Advancement of Science. Papers will be presented by Professor W. J. Beal, on "Testing Seeds"; by Professor R. C. Kedzie, on "The Ripening of Wheat"; and other essays, the subjects of which have not been announced, will be read by Professor S. W. Johnson, Patrick Barry, Professors J. H. Comstock, E. W. Hilgard, and A. J. Cook, Messrs. J. J. Thomas, L. B. Arnold, and E. Lewis Sturtevant, M. D.

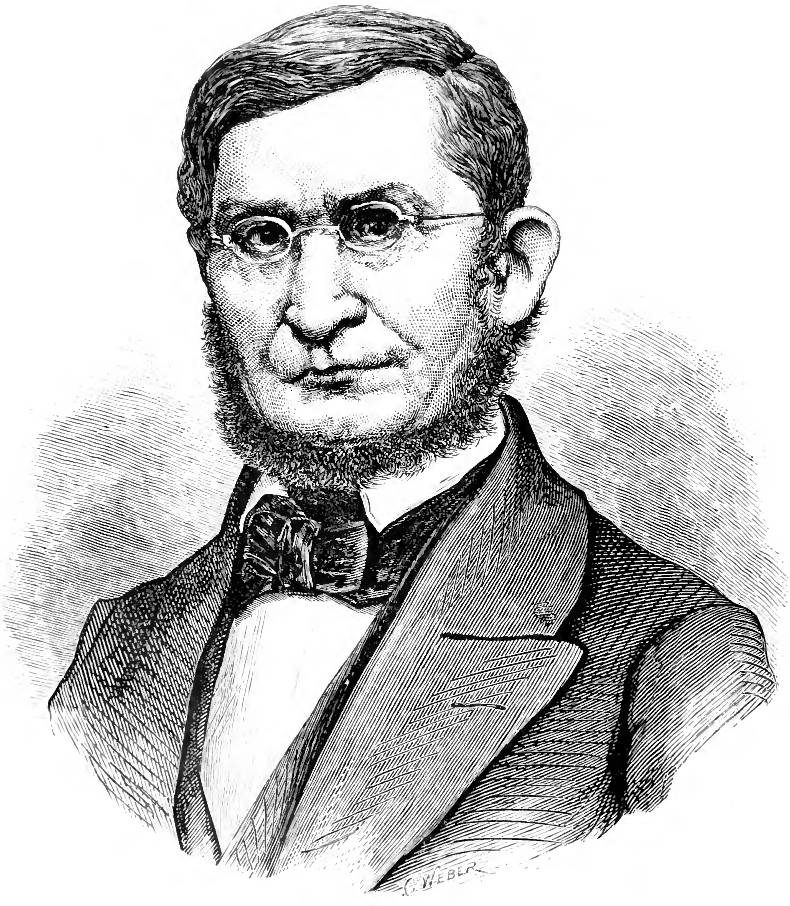
The meeting of the French Association for the Advancement of Science at Algiers was successful in point of numbers, at least, notwithstanding the troubles with Tunis. A great many members had arrived on the 11th of April, fresh ones were coming in every boat, and it was thought that the attendance would exceed a thousand.

Professor James Tennant, F. G. S., a well-known mineralogist, has recently died in London, at the age of seventy-three years. He was the possessor of one of the largest and most valuable collections of minerals, was for many years Professor of Geology and Mineralogy, afterward Professor of Mineralogy in King's College, London; he held the office of "Mineralogist to the Queen," and was consulted by the Government, as one of the best authorities on gems, with respect to the cutting of the Koh-i-noor diamond. He did useful work in preparing collections of minerals and fossils suitable for educational purposes and as a lecturer, and was author, in connection with the late Professor Ansted and the Rev. W. O. Mitchell, of the treatise on "Geology, Mineralogy, and Crystallography" in Orr's "Circle of the Sciences."

The death is reported of Mr. F. A. Nobert, the celebrated producer of test-plates for microscopists. He had been engaged for many years in ruling micrometers and diffraction plates, and produced one set of lines—his nineteenth band—equivalent to about 112,000 lines to the inch, which he believed could never be seen resolved in the microscope. Dr. Woodward eventually produced photographs of the finest of these lines; when Mr. Nobert ruled a new plate, the finest band of which—the twentieth—was of a fineness equivalent to about 224,000 lines to the inch.

The New York Electrical Society was formed in this city on the 8th of February last, with the purpose of bringing persons engaged in operations connected with electricity into closer connection and association with each other for improvement in knowledge of electric art and science, and for social intercourse. The first regular meeting of the society was held on the 2d of March, when the organization was completed. Its real work was begun at the meeting of March 16th, when a paper was read by Mr. F. W. Cushing on the "Harmonic Telegraph" of Professor Elisha Gray. The preliminary meeting was participated in by between thirty and forty electricians and telegraphists: more than two hundred members had been enrolled at the meeting of March 16th.

Sir Philip Egerton, Bart., M. P., one of the Vice-Presidents of the Geological Society, died in London, April 5th, in the seventy-fifth year of his age. He was chosen a Fellow of the Geological Society in 1829, and a Fellow of the Royal Society in 1831, and was also a Fellow of the Society of Antiquaries, antiquary to the Royal Academy, trustee of the British Museum, and one of the senate of London University. He was the author of fifty-one scientific papers, chiefly devoted to studies of fossil fishes, and generally published in the journal of the Geological Society, besides several papers in which he was joint author with other persons. He was owner of a collection of fossil fishes of remarkable value, it being but little inferior to that of the Earl of Enniskillen, which is, perhaps, the finest in the world.



CHARLES THOMAS JACKSON.

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THE RACES OF MANKIND.*

By E. B. TYLOR, F. R. S.

ANTHROPOLOGY finds race-differences most clearly in stature and proportions of limbs, conformation of the skull and the brain within, characters of features, skin, eyes, and hair, peculiarities of constitution, and mental and moral temperament.

In comparing races as to their stature, we concern ourselves not with the tallest or shortest men of each tribe, but with the ordinary or average-sized men who may be taken as fair representatives of their whole tribe. The difference of general stature is well shown where a tall and a short people come together in one district. Thus, in Australia the average English colonist of five feet eight inches looks clear over the heads of the five feet four inch Chinese laborers. Still more in Sweden does the Swede of five feet seven inches tower over the stunted Lapps, whose average measure is not much over five feet. Among the tallest of mankind are the Patagonians, who seemed a race of giants to the Europeans who first watched them striding along their cliffs draped in their skin cloaks ; it was even declared that the heads of Magalhaens's men hardly reached the waist of the first Patagonian they met. Modern travelers find, on measuring them, that they really often reach six feet four inches, their mean height being about five feet eleven inches—three or four inches taller than average Englishmen. The shortest of mankind are the Bushmen and related tribes in South Africa, with an average height not far exceeding four feet six inches. A fair contrast between the tallest and shortest races of mankind may be seen in Fig. 1, where a Patagonian is drawn side by side with a

* Abridged from Chapter III of "Anthropology: An Introduction to the Study of Man and Civilization." By Edward B. Tylor, D. C. L., F. R. S. New York: D. Appleton & Co. 1881.

Bushman, whose head only reaches to his breast. Thus, the tallest race of man is less than one fourth higher than the shortest, a fact which seems surprising to those not used to measurements. In general, the stature of the women of any race may be taken as about one sixteenth less than that of the men. Thus, in England a man of five feet eight inches and a woman of five feet four inches look an ordinary well-matched couple.

Not only the stature, but the proportions of the body, differ in men of various races. Care must be taken not to confuse real race-differ-

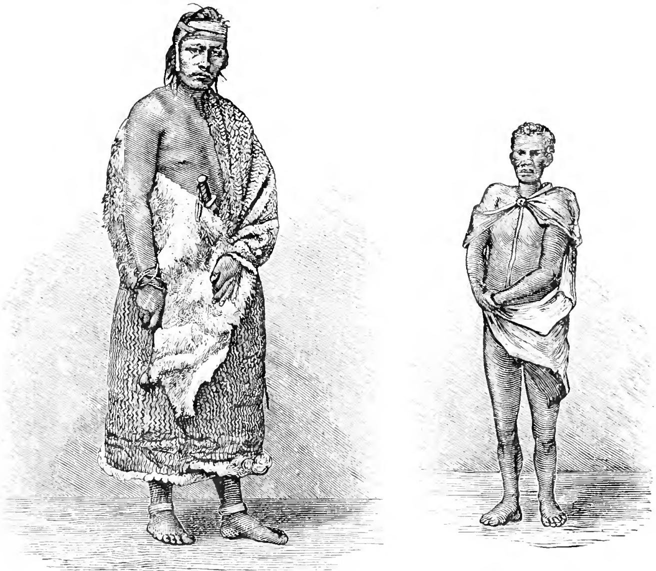


Fig. 1.—Patagonian and Bushman.

ences with the alterations made by the individual's early training or habit of life. A man's measure round the chest depends a good deal on his way of life, as do also the lengths of arm and leg, which are not even the same in soldiers and sailors. But there are certain distinctions which are inherited, and mark different races. Thus, there are long-limbed and short-limbed tribes of mankind. The African negro is remarkable for length of arm and leg, the Aymara Indian of Peru for shortness. Negro soldiers standing at drill bring the middle finger-tip an inch or two nearer the knee than white men can do, and some have been even known to touch the knee-pan. Such differences, however, are less remarkable than the general correspondence in bodily proportions of a model of strength and beauty, to whatever race he may belong. Even good judges have been led to forget the niceties of race-type and to treat the form of the athlete as everywhere one and the same. Thus, Benjamin West, the American painter, when he

came to Rome and saw the Belvedere Apollo, exclaimed, "It is a young Mohawk warrior!" Much the same has been said of the proportions of Zooloo athletes. Yet, if fairly-chosen photographs of Caffres be compared with a classic model, such as the Apollo, it will be noticed that the trunk of the African has a somewhat wall-sided straightness, wanting in the inward slope which gives fineness to the waist, and in the expansion below which gives breadth across the hips, these being two of the most noticeable points in the classic model which our painters recognize as an ideal of manly beauty.

In comparing races, one of the first questions that occurs is, whether people, who differ so much intellectually as savage tribes and civilized nations, show any corresponding difference in their brain. There is, in fact, a considerable difference. The most usual way of ascertaining the quantity of brain is to measure the capacity of the brain-case by filling skulls with shot or seed. Professor Flower gives as a mean estimate of the contents of skulls in cubic inches—Australian, seventy-nine; African, eighty-five; European, ninety-one. Eminent anatomists also think that the brain of the European is somewhat more complex in its convolutions than the brain of a negro or Hottentot. Thus, though these observations are far from perfect, they show a connection between a more full and intricate system of brain-cells and fibers, and a higher intellectual power, in the races which have risen in the scale of civilization.

The form of the skull itself has been to the anatomist one of the best means of distinguishing races. It is often possible to tell by inspection of a skull what race it belongs to. In comparing skulls, some of the most easily noticeable distinctions are the following:

When looked at from the vertical or top view, the proportion of breadth to length is seen as in Fig. 2. Taking the diameter from back

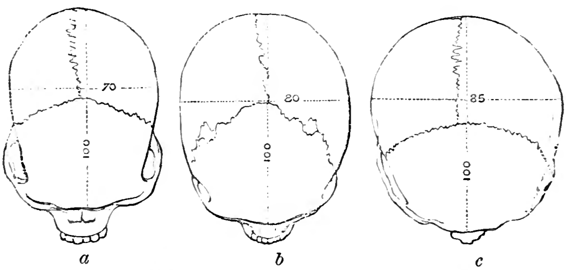


FIG. 2.—TOP VIEW OF SKULLS. *a*. Negro, index 70, dolichocephalic; *b*. European, index 80, mesocephalic; *c*, Samoyed, index 85, brachycephalic.

to front as 100, the cross diameter gives the so-called index of breadth, which is here about 70 in the negro (*a*), 80 in the European (*b*), and 85 in the Samoyed (*c*). Such skulls are classed respectively as *dolichocephalic*, or "long-headed"; *mesocephalic*, or "middle-headed"; and *brachycephalic*, or "short-headed." A model skull of a flexible

material like gutta-percha, if of the middle shape, like that of an ordinary Englishman, might, by pressure at the sides, be made long like a negro's, or by pressure at back and front be brought to the broad Tartar form. In the above figure it may be noticed that while some

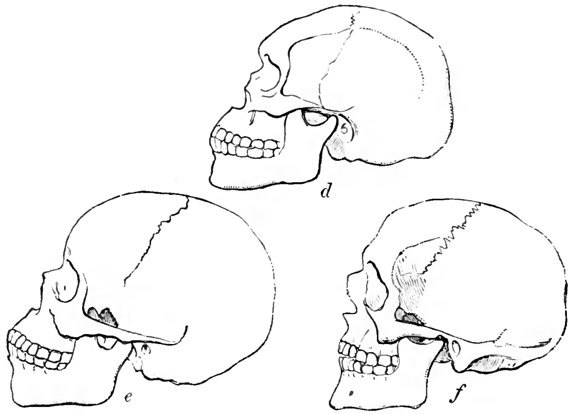


Fig. 3.—Side View of Skulls. *d*, Australian, prognathous; *e*, African, prognathous; *f*, European, orthognathous.

skulls, as *b*, have a somewhat elliptical form, others, as *a*, are ovoid, having the longest cross diameter considerably behind the center. Also in some classes of skulls, as in *a*, the zygomatic arches connecting the skull and face are fully seen; while in others, as *b* and *c*, the bulging of the skull almost hides them. In the front and back view of skulls, the proportion of width to height is taken in much the same

Fig. 4.—*a*, Swaheli; *b*, Persian.

way as the index of breadth just described. Next Fig. 3, which represents in profile the skulls of an Australian (*d*), a negro (*e*), and an Englishman (*f*), shows the strong difference in the facial angle between the two lower races and our own. The Australian and African

are *prognathous*, or "forward-jawed," while the European is *orthognathous*, or "upright-jawed." At the same time the Australian and African have more retreating foreheads than the European, to the disadvantage of the frontal lobes of their brain as compared with ours.

FIG. 5.—FEMALE PORTRAITS. *a*, Negro (W. Africa); *b*. Barolong (S. Africa); *c*. Hottentot; *d*, Gilyak (N. Asia); *e*, Japanese; *f*, Colorado Indian (N. America); *g*, English.

Thus the upper and lower parts of the profile combine to give the faces of these less civilized peoples a somewhat ape-like slope, as distinguished from the more nearly upright European face.

Let us now glance at the evident points of the living face. To some extent feature directly follows the shape of the skull beneath. Thus the contrast just mentioned, between the forward-sloping negro skull and its more upright form in the white race, is as plainly seen in the portraits of a Swaheli negro and a Persian, given in Fig. 4. On looking at the female portraits in Fig. 5, the Barolong girl (South Africa) may be selected as an example of the effect of narrowness of skull (*b*), in contrast with the broader Tartar and North American faces (*d*, *f*). She also shows the convex African forehead, while they, as well as the Hottentot (*c*), show the effect of high cheek-bones. The Tartar and Japanese faces (*d*, *e*) show the skew-eyelids of the Mongolian race. Much of the character of the human face depends on the shape of the softer parts—nose, lips, cheeks, chin, etc.—which are often excellent marks to distinguish race. Contrasts in the form of nose may even exceed that here shown between the aquiline of the Persian and the snub of the negro in Figs. 4 and 6. European travelers in Tartary in the middle ages described its flat-nosed inhabitants as having no noses at all, but breathing through holes in their faces. By pushing the tips of our own noses upward, we can in some degree imitate the manner in which various other races, notably the negro, show the opening of the nostrils in full face. Our thin, close-fitting lips differ in the extreme from those of the negro, well seen in the portrait

Fig. 6.—African Negro.

(Fig. 6) of Jacob Wainwright, Livingstone's faithful boy. With the purpose of calling attention to some well-marked peculiarities of the human face in different races, a small group of female faces (Fig. 5) is given, all young, and such as would be considered among their own

people as at least moderately handsome. Setting aside hair and complexion, there is still enough difference in the actual outline of the features to distinguish the negro, Caffre, Hottentot, Tartar, Japanese, and North American faces from the English face below.

The color of the skin, that important mark of race, may be best understood by looking at the darkest variety. The dark hue of the negro does not lie so deep as the innermost or true skin, which is substantially alike among all races of mankind. The negro, in spite of his name, is not black, but deep brown, and even this darkest hue does not appear at the beginning of life, for the new-born negro child is reddish-brown, soon becoming slaty-gray, and then darkening. Nor does the darkest tint ever extend over the negro's whole body, but his soles and palms are brown. The coloring of the dark races appears to be similar in nature to the temporary freckling and sunburning of the fair white race. On the whole, it seems that the distinction of color, from the fairest Englishman to the darkest African, has no hard and fast lines, but varies gradually from one tint to another.

The natural hue of skin farthest from that of the negro is the complexion of the fair race of Northern Europe, of which perfect types are to be met with in Scandinavia, North Germany, and England. In such fair or blonde people the almost transparent skin has its pink tinge by showing the small blood-vessels through it. In the nations of Southern Europe, such as Italians and Spaniards, the browner complexion to some extent hides this red, which among darker peoples in other quarters of the world ceases to be discernible. Thus the difference between light and dark races is well observed in their blushing, which is caused by the rush of hot red blood into the vessels near the surface of the body. The contrary effect, paleness, caused by retreat of blood from the surface, is in like manner masked by dark tints of skin.

The range of complexion among mankind, beginning with the tint of the fair-whites of Northern Europe and the dark-whites of Southern Europe, passes to the brownish-yellow of the Malays, and the full-brown of American tribes, the deep-brown of Australians, and the black-brown of negroes. Until modern times these race-tints have generally been described with too little care. Now, however, the traveler, by using Broca's set of pattern-colors, records the color of any tribe he is observing, with the accuracy of a mercer matching a piece of silk. The evaporation from the human skin is accompanied by a smell which differs in different races. This peculiarity, which not only indicates difference in the secretions of the skin, but seems connected with liability to certain fevers, etc., is a race-character of some importance.

The part of the human body which shows the greatest variety of color in different individuals is the iris of the eye. This is the more noticeable because the adjacent parts vary particularly little among

mankind. Professor Broca, in his scale of colors of eyes, arranges shades of orange, green, blue, and violet-gray. But one has only to look closely into any eye to see the impossibility of recording its complex pattern of colors; indeed, what is done is to observe it from a distance, so that its tints blend into one uniform hue. It need hardly be said that what are popularly called black eyes are far from having the iris really black like the pupil; eyes described as black are commonly of the deepest shades of brown or violet. These so-called black eyes are by far the most numerous in the world, belonging not only to brown-black, brown, and yellow races, but even prevailing among the darker varieties of the white race, such as Greeks and Spaniards. In races with the darker skin and black hair, the darkest eyes generally prevail, while a fair complexion is usually accompanied by the lighter tints of iris, especially blue.

From ancient times, the color and form of the hair have been noticed as distinctive marks of race. Thus Strabo mentions the Ethiopians as black men with woolly hair, and Tacitus describes the German warriors of his day with their fierce blue eyes and tawny hair. As to color of hair, the most usual is black, or shades so dark as to be taken for black, which belongs not only to the dark-skinned Africans and Americans, but to the yellow Chinese and the dark-whites, such as Hindoos or Jews. In the fair-white peoples of Northern Europe, on the contrary, flaxen or chestnut hair prevails. Thus we see that there is a connection between fair hair and fair skin, and dark hair and dark skin. But it is impossible to lay down a rule for intermediate tints, for the red-brown or auburn hair common in fair-skinned peoples occurs among darker races, and dark-brown hair has a still wider range. Our own extremely mixed nation shows every

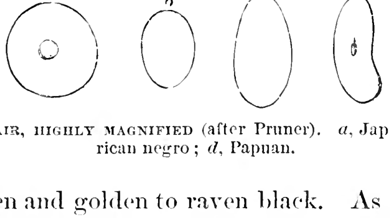


Fig. 7.—Sections of Hair, highly magnified (after Pruner). *a*, Japanese; *b*, German; *c*, African negro; *d*, Papuan.

variety, from flaxen and golden to raven black. As to the form of the hair, its well-known differences may be seen in the female portraits in Fig. 5, where the Africans on the left show the woolly or frizzy kind, where the hair naturally curls into little corkscrew spirals, while the Asiatic and American heads on the right have straight hair like a horse's mane. Between these extreme kinds are the flowing or wavy hair, and the curly hair which winds in large spirals; the English hair in the figure is rather of the latter variety. If cross-sections of single hairs are examined under the microscope, their differences of form are seen as in four of the sections by Pruner-Bey (Fig. 7). The almost

circular Mongolian hair (*a*) hangs straight; the more curly European hair (*b*) has an oval or elliptical section; the woolly African hair (*c*) is more flattened; while the frizzy Papuan hair (*d*) is a yet more extreme example of the flattened ribbon-like kind. Not only the color and form of the hair, but its quantity, vary in different races.

That certain races are constitutionally fit, and others unfit, for certain climates, is a fact which the English have but too good reason to know. It is well known that races are not affected alike by certain diseases. While in equatorial Africa or the West Indies, the coast-fever and yellow fever are so fatal or injurious to the new-come Europeans, the negroes, and even mulattoes, are almost untouched by this scourge of the white nations. On the other hand, we English look upon measles as a trifling complaint, and hear with astonishment of its being carried into Feejee, and there, aggravated, no doubt, by improper treatment, sweeping away the natives by thousands. It is plain that nations moving into a new climate, if they are to flourish, must become adapted in body to the new state of life. Fitness for a special climate, being matter of life or death to a race, must be reckoned among the chief of race-characters.

Travelers notice striking distinctions in the temper of races. There seems no difference of condition between the native Indian and the African negro in Brazil to make the brown man dull and sullen, while the black is overflowing with eagerness and gayety. So, in Europe, the unlikeness between the melancholy Russian peasant and the vivacious Italian can hardly depend altogether on climate and food and government. There seem to be in mankind inbred temperament and inbred capacity of mind. History points the great lesson that some races have marched on in civilization while others have stood still or fallen back, and we should partly look for an explanation of this in

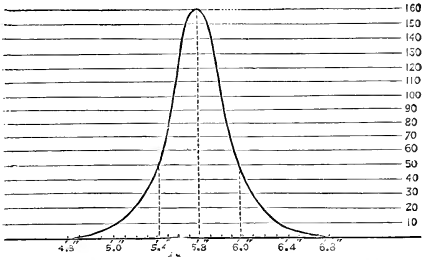


FIG. 8.—RACE OR POPULATION ARRANGED BY STATURE (Quetelet's method).

differences of intellectual and moral powers between such tribes as the native Americans and Africans, and the old-world nations who overmatch and subdue them. In measuring the minds of the lower races, a good test is, how far their children are able to take a civilized education. The account generally given by European teachers who have had the children of lower races in their schools is that, though these

often learn as well as the white children up to about twelve years old, they then fall off, and are left behind by the children of the ruling race.

It will be well now to examine more closely what a race is. Single portraits of men and women can only in a general way represent the nation they belong to, for no two of its individuals are really alike, not even brothers. What is looked for in such a race-portrait is the gen-

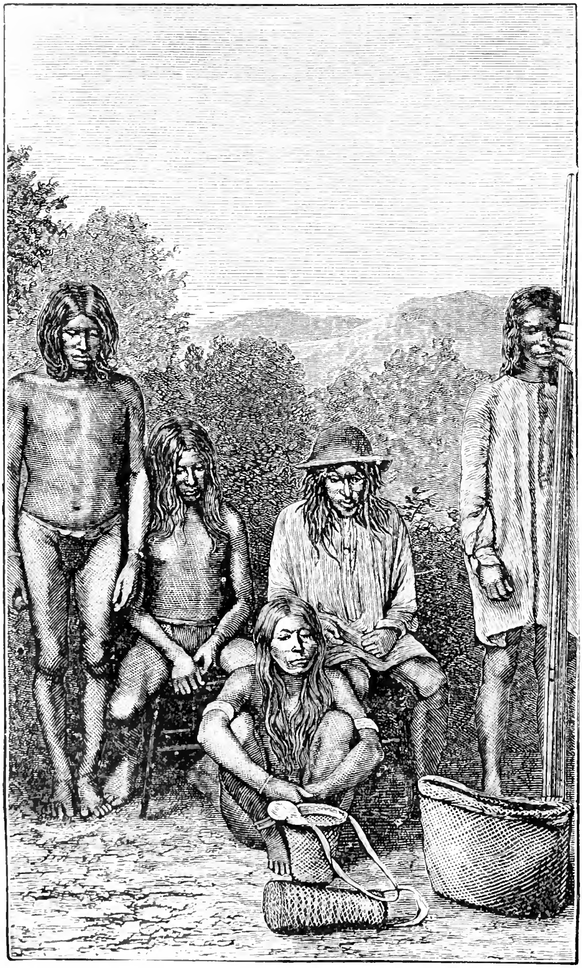


Fig. 9.—Caribs.

eral character belonging to the whole race. It is an often-repeated observation of travelers that a European landing among some people unlike his own, such as Chinese, or Mexican Indians, at first thinks them all alike. After days of careful observation he makes out their individual peculiarities, but at first his attention is occupied with the

broad typical characters of the foreign race. It is just this broad type that the anthropologist desires to sketch and describe, and he selects as his examples such portraits of men and women as show it best. It is even possible to measure the type of a people. To give an idea of the working of this problem, let us suppose ourselves to be examining Scotchmen, and the first point to be settled how tall they are. Obviously there are some few as short as Lapps, and some as tall as Patagonians ; these very short and tall men belong to the race, and yet are not its ordinary members. If, however, the whole population were measured and made to stand in order of height, there would be a crowd of men about five feet eight inches, but much fewer of either five feet four inches or six feet, and so on till the numbers decreased on either side to one or two giants, and one or two dwarfs. This is seen in Quetelet's diagram, Fig. 8, where the heights or ordinates of the binomial curve show the numbers of men of each stature, decreasing both ways from the central five feet eight inches, which is the stature of the mean or typical man. Here, in a total of near 2,600 men, there are 160 of five feet eight inches, but only about 150 of five feet seven inches or five feet nine inches, and so on, till not even ten men are found so short as five feet, or so tall as six feet four inches.

Fig. 10.—Malay Mother and Half-caste Daughters.

It thus appears that a race is a body of people comprising a regular set of variations, which center round one representative type. In the same way a race or nation is estimated as to other characters.

The people whom it is easiest to represent by single portraits are

uncivilized tribes, in whose food and way of life there is little to cause difference between one man and another, and who have lived together and intermarried for many generations. Thus Fig. 9, taken from a photograph of a party of Caribs, is remarkable for the close likeness running through all. In such a nation the race-type is peculiarly easy to make out. It is by no means always thus easy to represent a whole population. To see how difficult it may be, one has only to look at an English crowd, with its endless diversity. But, to get a view of the problem of human varieties, it is best to attend to the simplest cases first, looking at some uniform and well-marked race, and asking what in the course of ages may happen to it.

The first thing to be noticed is its power of lasting. Where a people lives on in its own district, without too much change in habits, or mixture with other nations, there seems no reason to expect its type to alter. The Egyptian monuments show good instances of this permanence. Indeed, the ancient Egyptian race, who built the Pyramids, and whose life and toil are pictured on the walls of the tombs, are with little change still represented by the fellahs of the villages, who carry on the old labor under new tax-gatherers. Thus, too, the Ethiopians on the early Egyptian bass-reliefs may have their counterparts picked out still among the White Nile tribes, while we recognize in the figures of Phœnician or Israelite captives the familiar Jewish profile of our own day. Thus there is proof that a race may keep its special characters plainly recognizable for over thirty centuries, or a hundred generations. And this permanence of type may more or less remain when the race migrates far from its early home, as when African ne-

Fig. 11.—Cafusa Woman.

groes are carried into America, or Israelites naturalize themselves from Archangel to Singapore. Where marked change has taken place in the appearance of a nation, the cause of this change must be sought in intermarriage with foreigners, or altered conditions of life, or both.

The result of intermarriage or crossing of races is familiar to all

English people in one of its most conspicuous examples, the cross between white and negro called mulatto. The mulatto complexion and

Fig. 12.—Aheta (Negrito), Philippine Islands.

hair are intermediate between those of the parents, and new intermediate grades of complexion appear in the children of white and

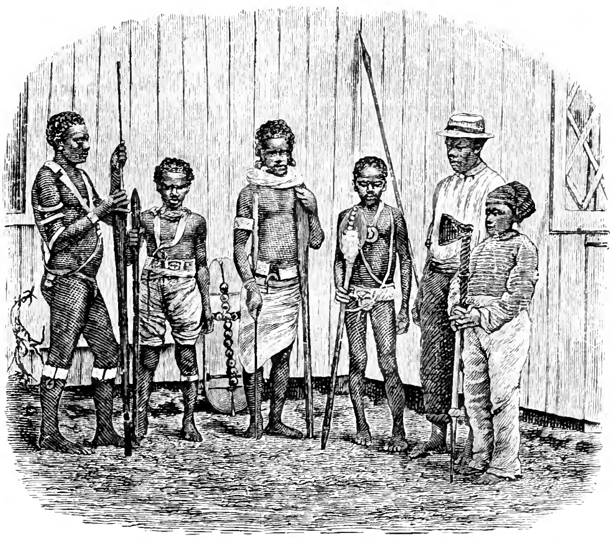


Fig. 13.—Melanesians.

mulatto, called quadroon or quarter-blood, and so on; on the other hand, the descendants of negro and mulatto, called sambo, return toward the full negro type. This intermediate character is the general nature of crossed races, but with more or less tendency to revert to one or other of the parent types. To illustrate this, Fig. 10 gives the portrait of a Malay mother and her half-caste daughters, the father being a Spaniard; here, while all the children show their mixed race, it is sometimes the European and sometimes the Malay cast of features that prevails. The effect of mixture is also traceable in the hair, as may often be well noticed in a mulatto's crimped, curly locks, between the straighter European and the woolly African kind. The Cafusas of Brazil, a peculiar cross between the native tribes of the land and the imported negro slaves, are remarkable for their hair, which rises in a curly mass, forming a natural periwig which obliges the wearers to stoop low in passing through their hut-doors. This is seen in the portrait of a Cafusa (Fig. 11), and seems easily accounted for by the long stiff hair of the native American having acquired in some degree the negro frizziness.

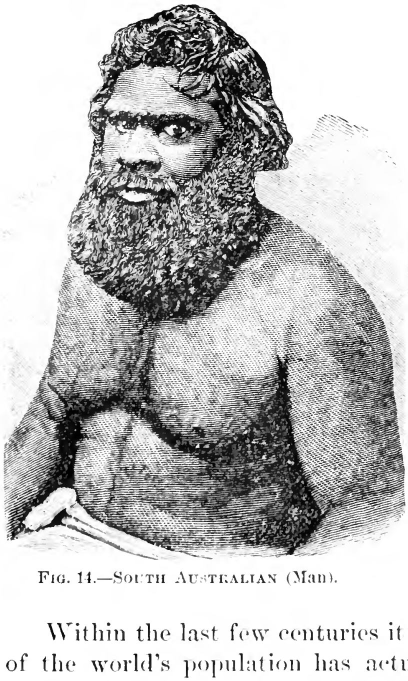


Fig. 14.—South Australian (Man).

Fig. 15.—South Australian (Woman).

Within the last few centuries it is well known that a large fraction of the world's population has actually come into existence by race-crossing. This is nowhere so evident as on the American Continent, where since the Spanish conquest such districts as Mexico are largely peopled by the mestizo descendants of Spaniards and native Americans, while the importation of African slaves in the West Indies has given rise to a mulatto population. By taking into account such inter-

crossing of races, anthropologists have a reason to give for the endless shades of diversity among mankind, without attempting the hopeless task of classifying every little uncertain group of men into a special race. Among the natives of India, a variety of complexion and feature is found which can not be classified exactly by race. But it must be remembered that several very distinct varieties of men have contributed to the population of the country. So in Europe, taking the fair nations of the Baltic and the dark nations of the Mediterranean as two distinct races or varieties, their intercrossing may explain the infinite diversity of brown hair and intermediate complexion to be met with. If, then, it may be considered that man was already divided into a few great main races in remote antiquity, their intermarriage

FIG. 16.—DRAVIDIAN HILL-MAN (after Fryer).

through ages since will go far to account for the innumerable slighter varieties which shade into one another.

It is not enough to look at a race of men as a mere body of people happening to have a common type or likeness. For the reason of their likeness is plain, and indeed our calling them a race means that we consider them a breed whose common nature is inherited from common ancestors. Now, experience of the animal world shows that a race or breed, while capable of carrying on its likeness from generation to generation, is also capable of varying. It must be admitted that our knowledge of the manner and causes of race-variation among mankind is still very imperfect. The great races, black, brown, yellow, white, had already settled into their well-known characters before

written record began, so that their formation is hidden far back in the prehistoric period. Nor are alterations of such amount known to have taken place in any people within the range of history.

That there is a real connection between the color of races and the climate they belong to, seems most likely from the so-called black peoples. Ancient writers were satisfied to account for the color of the Ethiopians by saying that the sun had burned them black, and, though modern anthropologists would not settle the question in this off-hand way, yet the map of the world shows that this darkest race-type is principally found in a tropical climate. The main line of black races

Fig. 17.—Calmuck (after Goldsmid).

stretches along the hot and fertile regions of the equator, from Guinea in West Africa to that great island of the Eastern Archipelago, which has its name of New Guinea from its negro-like natives. The type of the African negro race perhaps shows itself most perfectly in the nations near the equator, as in Guinea, but it spreads far and wide over the continent, shading off by crossing with lighter-colored races on its borders, such as the Berbers in the north, and the Arabs on the east coast. As the race spreads southward into Congo and the Caffre regions, there is noticed a less full negro complexion and feature, look-

ing as though migration from the central region into new climates had somewhat modified the type. There are found in the Malay Peninsula and the Philippines scanty forest-tribes apparently allied to the Andamaners and classed under the general term Negritos (i. e., "little blacks"), seeming to belong to a race once widely spread over this part of the world, whose remnants have been driven by stronger new-come races to find refuge in the mountains. Fig. 12 represents one of them, an Aheta from the island of Luzon. Lastly come the wide-spread and complicated varieties of the Eastern negro race in the region known as Melanesia, the "black islands," extending from New Guinea to Feejee. The group of various islanders (Fig. 13), belonging to Bishop

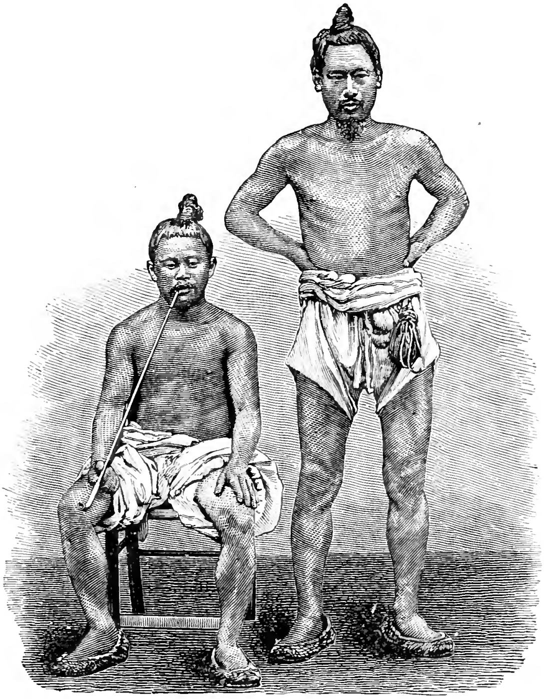


FIG. 18.—COREANS.

Patteson's mission, shows plainly the resemblance to the African negro, though with some marked points of difference, as in the brows being more strongly ridged, and the nose being more prominent, even aquiline—a striking contrast to the African. The great variety of color in Melanesia, from the full brown-black down to chocolate or nut-brown, shows that there has been much crossing with lighter populations. Finally, the Tasmanians were a distant outlying population belonging to the Eastern blacks.

In Australia, there appears a thin population of roaming savages,

strongly distinct from the blacker races of New Guinea at the north, and Tasmania at the south. The Australians, with skin of dark chocolate-color, may be taken as a special type of the brown races of man. While their skull is narrow and prognathous like the negro's, it differs from it in special points, and has peculiarities which distinguish it very certainly from that of other races. In the portraits of Australians (Figs. 14, 15), there may be noticed the heavy brows and projecting jaws, the wide but not flat nose, the full lips, and the curly but not woolly black hair. On the continent of India, the Dravidian hill-tribes present the type of the old dwellers in South and Central India before the conquest by the Aryan Hindoos. Fig. 16 represents one of the ruder Dravidians, from the Travancore forests.

Fig. 19.—Finn (Man).

Fig. 20.—Finn (Woman).

The Mongoloid type of man has its best marked representatives on the vast steppes of Northern Asia. Their skin is brownish-yellow, the hair of the head black, coarse, and long, but face-hair scanty. Their skull is characterized by breadth, projection of cheek-bones, and forward position of the outer edge of the orbits, which, as well as the slightness of brow-ridges, the slanting aperture of the eyes, and the snub-nose, are observable in Fig. 17, and in Fig. 5 (*d*). The Mongoloid race is immense in range and numbers. The great nations of South-east Asia show their connection with it in the familiar complexion and features of the Chinese and Japanese. Fig. 18 gives portraits from Corea. In his wide migrations over the world, the Mongoloid, through change of climate and life, and still further by intermarriage with

other races, loses more and more of his special points. It is so in the southeast, where in China and Japan the characteristic breadth of skull is lessened. In Europe, where from remotest antiquity hordes of Tartar race have poured in, their descendants have often preserved in their languages, such as Hungarian and Finnish, clearer traces of their Asiatic home than can be made out in their present types of com-

FIG. 21.—DYAKS.

plexion and feature. Yet the Finns (Figs. 19 and 20) have not lost the race-differences which mark them off from the Swedes among whom they dwell, and the stunted Lapps show some points of likeness to their Siberian kinsfolk.

On the Malay Peninsula, at the extreme southeast corner of Asia, appear the first members of the Malay race, seemingly a distant branch

of the Mongoloid, which spreads over Sumatra, Java, and other islands of the Eastern Archipelago. Fig. 21 shows the Dyaks of Borneo, who represent the race in its wilder and perhaps less mixed state. The Micronesians and Polynesians show connection with the Malays in language, and more or less in bodily make. But they are not Malays proper, and there are seen among them high faces, narrow noses, and small mouths, which remind us of the European face. The Maoris

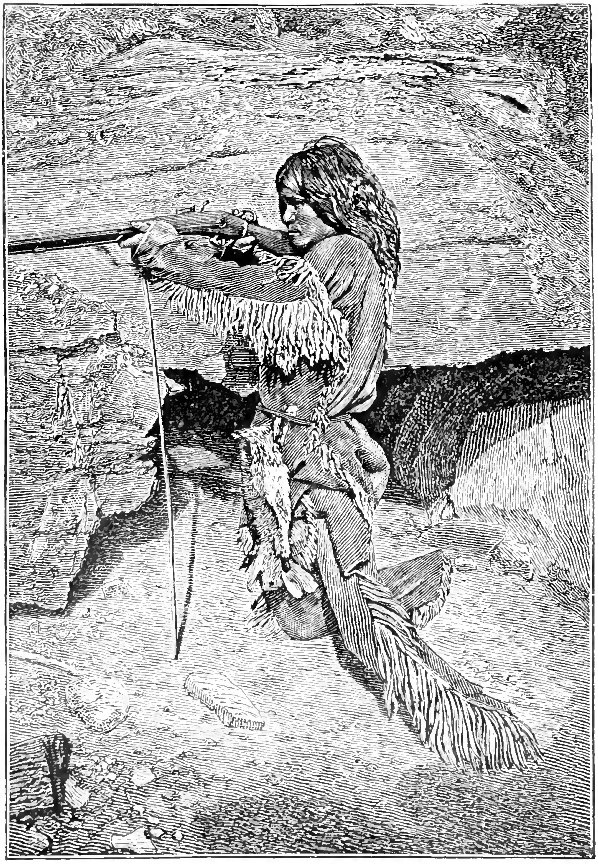


Fig. 22.—Colorado Indian (North America).

are still further from being pure Malays, as is seen by their more curly hair, often prominent and even aquiline noses.

Turning now to the double continent of America, we find in this New World a problem of race remarkably different from that of the Old World. The traveler who should cross the earth from Nova Zembla to the Cape of Good Hope or Van Diemen's Land would find in its various climates various strongly-marked kinds of men, white, yellow, brown, and black. But, if Columbus had surveyed America from

the Arctic to the Antarctic regions, he would have found no such extreme unlikeness in the inhabitants. Apart from the Europeans and Africans who have poured in since the fifteenth century, the native Americans in general might be, as has often been said, of one race. Not that they are all alike, but their differences in stature, form of skull, feature, and complexion, though considerable, seem variations of a secondary kind. The race to which most anthropologists refer the native Americans is the Mongoloid of Eastern Asia, who are capable of accommodating themselves to the extremest climates, and who by the form of skull, the light-brown skin, straight black hair, and black eyes, show considerable agreement with the American tribes. Fig.

FIG. 23.—SWEDES.

22 represents the wild hunting-tribes of North America in one of the finest forms now existing, the Colorado Indians.

Though commonly spoken of as one variety of mankind, it is plain that the white men are not a single uniform race, but a varied and mixed population. It is a step toward classing them to separate them into two great divisions, the dark-whites and fair-whites (*melanochroi*, *xanthochroi*). Ancient portraits have come down to us of the dark-white nations, as Assyrians, Phœnicians, Persians, Greeks, Romans; and when beside these are placed moderns such as the Andalusians, and the dark Welshmen or Bretons, and people from the Caucasus, it will be evident that the resemblance running through all these can only be in broad and general characters. They have a dusky or

brownish-white skin, black or deep-brown eyes, black hair, mostly wavy or curly; their skulls vary much in proportions, though seldom extremely broad or narrow, while the profile is upright, the nose straight or aquiline, the lips less full than in other races. Fig. 23, a group of Swedes, represents the fair-whites, whose transparent skin, flaxen hair, and blue eyes may be seen as well, though not as often, in England as in Scandinavia or North Germany. The intermarriage of the dark and fair varieties, which has gone on since early times, has resulted in numberless varieties of brown-haired people, between fair and dark in complexion. But as to the origin and first home of the fair and dark races

Fig. 24.—Gypsy.

themselves, it is hard to form an opinion. Language does much toward tracing the early history of the white nations, but it does not clear up the difficulty of separating fair-whites from dark-whites. Both sorts have been living united by national language, as at this day German is spoken by the fair Hanoverian and the darker Austrian. Among Keltic people, the Scotch Highlanders often remind us of the tall, red-haired Gauls described in classical history, but there are also passages which prove that smaller darker Kelts like the modern Welsh and Bretons existed then as well. A mixture of the white and brown races seems to have largely formed the population of countries where they meet. The Moors of North Africa, and many so-called Arabs

who are darker than white men, may be thus accounted for. It is thus that in India millions who speak Hindoo languages show by their tint that their race is mixed between that of the Aryan conquerors of the land and its darker indigenes. An instructive instance of this very combination is to be seen in the gypsies, low-caste wanderers who found their way from India and spread over Europe not many centuries since. Fig. 24, a gypsy woman from Wallachia, is a favorable type of these latest incomers from the East, whose broken-down Hindoo dialect shows that part of their ancestry comes from our Aryan forefathers, while their complexion, swarthiest in the population of our country, marks also descent belonging to a darker zone of the human species.

Thus to map out the nations of the world among a few main varieties of man, and their combinations, is, in spite of its difficulty and uncertainty, a profitable task. But to account for the origin of these great primary varieties or races themselves, and exactly to assign to them their earliest homes, can not be usefully attempted in the present scantiness of evidence.

EUROPEAN SCHOOLS OF FORESTRY.

By N. H. EGLESTON.

THE word "forestry" has not yet come into familiar use in this country, and its meaning is understood only by the few; "school of forestry" is still less comprehensible. It is only natural that our people, occupying a region covered to a great extent with a dense and varied growth of trees, in regard to which no apprehension of deficiency has been suggested until within a comparatively short time, should have entertained little thought of the forest as a thing to be specially cared for and cultivated. Much less should it have occurred to them to make its maintenance an object of scientific study, to put the school and the wood, education and trees, into close association, and to think and speak of "schools of forestry."

Both these terms, however, are well understood abroad, and the time has come, in the changed condition of things here, when we should know what they mean, and that practically.

The "school of forestry," or whatever equivalent may be used in different countries, signifies an organization for the purpose of giving instruction in regard to all that pertains to the growth of trees, especially in masses, and their management, including their natural history, their adaptation to the arts, and their influence upon human welfare. It regards the forest in altogether a different light from that in which it is considered with us, or in fact from that in which it has been considered in any country until within a comparatively recent pe-

riod. Instead of an accidental growth of trees, spared from the general clearing of the ground, which have been suffered to come up in a hap-hazard sort of way, exposed to assault and damage of various kinds, from insects, from browsing cattle allowed to roam freely among them, and from the carelessness, if not the wanton waste, of man, the forest is regarded as a growth carefully provided for, the conditions of its increase are diligently studied beforehand, and all means are used to develop it to the fullest measure of its value according to the purpose for which its cultivation has been undertaken. In short, forestry looks upon the growth of a piece of woods as we look upon the growth of plants in a garden, or a crop in the field of a farmer, as the result both of science and art. Only it is a nobler growth than these, and requires a higher science and nicer art, inasmuch as the trees measure their age by centuries and not by months or seasons, as do the ordinary crops of the garden and the field, and because they have important relations, controlling relations even to agriculture itself, to climate, to commerce, and the industrial arts, and so to the highest interests of national life.

The work of forestry, as understood in Europe, contemplates not only the proper care of existing woodlands, but the replanting of districts which have been stripped of their forests, and also the planting of forests in new places, where such planting may be advantageously done. Schools of forestry have their origin in the desire to accomplish this most successfully. The growth of a forest is the work of a century, and even more. It is not properly to be undertaken with only the limited intelligence or care with which we cultivate the annual crops of our fields. If the work is begun without adequate preparation, or is conducted in a faulty manner, the mistake can not be remedied soon, if at all. If one makes a mistake in the culture of ordinary crops, he can correct it the next year; but, if he plants a forest on an erroneous plan, the mistake is not one of a year, but of a hundred, or even two hundred years. Not only is it necessary that the botany of the trees should be understood, the nature and habits of the various species be studied, and their adaptations to different soils and situations, as well as to different practical uses when grown, be regarded, but the laws of meteorology are to be considered and conformed to. The knowledge of geology and mineralogy is also involved, as well as the laws of mechanics. Indeed, no sooner is the subject taken into consideration in its true character, than it is seen to be interwoven with a very large range of studies, so that something like schools of forestry seem almost at once desirable, if not indispensable.

The beginning of forest schools may be dated from 1770, when Frederick the Great established a course of theoretical instruction in forestry at Berlin. This, however, was irregular, dependent upon the competency of the professors at the university, for the time being, to

give instruction upon the subject. The course was greatly deficient, at the best, on account of its entire lack of technical teaching. This defect, felt more and more, finally led to the establishment of an academy for forest instruction at Berlin in 1821, under the general superintendence of Pfeil, then *Oberforstrath.* The academy was not organically connected with the university, but was brought into such an association with it that the professors and apparatus of instruction belonging to the university could be used for teaching the fundamental and accessory sciences, while technical forestry was taught by professors in the academy specially qualified for the work. This arrangement, however, did not prove satisfactory. Too much prominence was given to the accessory sciences, and too little to forestry proper. Especially was the lack of sufficient instruction in practical forestry felt, there being no suitable woodland in the neighborhood of Berlin in which the theoretical instruction could be practically illustrated and applied. Excursions to distant forests, which could be made only infrequently, did not meet the want. On the advice of the superintendent, seconded by the energetic support of the two Humboldts, the academy was removed in 1830 to Neustadt-Eberswalde, about twenty-four miles northeast of Berlin, under the name of the High Institution for Forest Science. The school was now in the immediate vicinity of two large forest districts, affording every facility for instruction in practical forestry. The superintendent of the academy was made also administrator of the forest districts. Associated with him, as instructor in forestry proper, were two others as teachers of the natural sciences and of mathematics and geodesy. At the same time a teacher of Prussian jurisprudence, with particular reference to forest matters, was added, and, after an interval of twenty years, a second teacher of forest science was appointed. Since 1866 important changes have been made in the organization of the academy, and the number of instructors has been largely increased. There are now three teachers of forest science, a teacher of mathematics, physics, mechanics, and meteorology; one of chemistry, mineralogy, and geognosy; one of botany, one of zoölogy, and one of jurisprudence. In addition, there are a royal chief forest officer, as assistant teacher of road-construction, geodesy, and plan-drawing, and also a chemist as assistant teacher of geology. The principal forest meteorological station of Germany is also in connection with this school.

The course of instruction in the schools of forestry extends from two years to two and a half, or five semesters, the tendency having been constantly to protract the time. The course at Neustadt-Eberswalde embraces five semesters. The branches taught are arranged in three groups, viz., "Fundamental Sciences," "Principal Sciences," and "Secondary Sciences." Under the heading of "Fundamental Sciences" are included: *1. Natural Sciences.*—Chemistry, theoretic and applied; physics and meteorology; mineralogy and geognosy; botany, and

forest botany in particular, with anatomy of plants, vegetable physiology and pathology, and botanical excursions; microscopy; zoölogy, with especial study of forest insects, preparations, and excursions: to all of which 840 hours are allotted. *2. Mathematics.*—Geodesy; interest and rent account; wood-measuring; surveying and leveling exercises; plan-drawing exercises: 440 hours. *3. Economical Sciences.*—Public economy and finances: 48 hours. Whole time allotted to "Fundamental Sciences," 1,328 hours. In the "Principal Sciences" are included what relate especially to forests, their cultivation, protection, technics in various branches, legal and customary usages, etc., with forest excursions: to all of which 980 hours are allotted. In the "Secondary Sciences" are jurisprudence (civil and criminal law, constitutional rights, etc.), construction of roads, and shooting exercises: to which 340 hours are given. Of the total, 2,648 hours of instruction, 50 per cent. are given to the "fundamental," 37 per cent. to the "principal," and 13 per cent. to the "secondary" sciences. The average time of lessons, counting the five semesters as including ninety-three weeks, is 28·5 hours per week, or 4·9 hours per day. From this it will be seen that nearly five hours are given to lectures each day. Nearly as much more time is expected to be given to study, making almost ten hours of daily work for the students. If we compare this with the average time during which the students in our colleges are employed, it will be seen that a course of instruction at one of these forest academies is more than equivalent, in the amount of work done, to an ordinary college course.

The forest schools, as at present existing, may be divided into three classes, according as they are forest schools strictly and independently—that is, schools situated in the forest as well as teaching the art of forest management—or as they form only a part of the general course of instruction at the university or polytechnic school; or as, again, they are united with agricultural schools, and the attempt is made to teach forestry and agriculture together. There has been of late years a good deal of discussion, in Germany especially, as to which of these arrangements is to be preferred. The academies at Neustadt-Eberswalde, Münden, Eisenach, and at Nancy, in France, are examples of the first class. Those at Giessen, at the Polytechnic School at Zürich and the projected arrangement at the university of Munich, are examples of the second class; while the establishments at Hohenheim, Vienna, St. Petersburg, and Stockholm, are examples of the third class.

On behalf of the first class it is urged that when the academy is located in the forest there will be greater facilities for the practical study of all that relates to the growth of trees, their influence upon climate, and the like. On behalf of a connection of the forest academies with the universities and polytechnic schools or with schools of agriculture, it is urged that this would be an economical arrange-

ment because only the technical teaching of forestry would have to be provided for, instruction in the fundamental and allied sciences being already abundantly secured in the necessary endowment of the ordinary educational establishments. The argument for the union of the separate forest schools with the universities, as put by Dr. Richard Hess, formerly Professor of Forestry and now director of the Forestry Department of the University of Giessen, in a recent work of his, may be taken as a fair exhibition of the reasoning of those who favor the union of the forest schools with the universities. He claims that the universities can always command for their various chairs men of the highest ability, and this, in the first place, because the position of such a professor is the most independent one, the instructors in the forest schools being dependent upon the director ; secondly, because the universities have better libraries and apparatus than the forest schools can have by themselves ; thirdly, the natural stimulation of colleagues in allied chairs is a powerful motive to excellence ; fourthly, the latest developments of science in the related departments of instruction will be found in the universities ; fifthly, the professors in connection with the universities receive a better income than those in the isolated forest schools ; and, finally, the academic atmosphere of the great university is of value, and helpful to professors and students alike. These reasons are forcibly urged in addition to those economical considerations which we have already mentioned. Professor Hess also adduces the practical fact that the forests of Hesse show the very best management, and are visited by foresters from abroad on this account, and that the forest management of Hesse took a high position at the Congress of Foresters held in connection with the Vienna Exposition in 1873.

The tendency of opinion, especially in the central and southern portions of Germany, seems to be in favor of attaching the forest academies to the universities. More and more there is demanded, in those who are called to important positions in the forestry service, the most thorough academical education, and one now has very little chance of gaining a high position in the management of the government forests who has not had a complete university education. Without this he can hope to occupy only a subordinate place. The tendency of the opinion of those most competent to judge in the case is shown also by the fact that at a convention of foresters held at Freyburg in 1874, and numbering three hundred and sixty-nine members, it was declared unanimously that the isolated system of forest instruction will no longer suffice, and the study of forestry in connection with the universities was favored.

One of the most recently established schools is that at Münden under the directorship of Dr. Gustav Heyer. Its management is like that at Neustadt-Eberswalde, and the average number of students has been about seventy-five. The Central Forest Institute at Aschaffen-

burg, Bavaria, one of the most distinguished schools, has grown out of a forest institute established originally in 1807, which by a decree of the Government in 1874 was united with the University of Munich. It is under the direction of Stumpf, who is assisted by five professors. This school has had the benefit and honor of the labors of Dr. Ernst Ebermayer, whose work on the "Physical Influences of Forests on the Earth and Air," published in 1873, in two volumes octavo, ranks as one of the most important treatises upon this subject.

The Royal Saxon Forest Academy at Tharandt is justly distinguished. It is now under the care of Dr. J. F. Judeich, who was president of the jury of award on exhibitions of forestry at Vienna in 1873. The course of instruction occupies two years and a half, under a director aided by four professors and two assistants. The average attendance of students is about fifty, more than half of whom are foreigners. The number in attendance has lately been much increased, and several Americans are reported among them.

In Würtemberg is the agricultural and forestral academy at Hohenheim, which has grown out of two separate institutions founded in 1818, and united two years afterward. It was reorganized in 1865, and is now one of the most important of the German schools, its course of instruction both in agriculture and forestry being very full. It is located on a princely estate near Stuttgart. It has a noble park of twenty acres, and extensive plantations or nurseries of trees and plants both native and foreign. Between seven and eight hundred acres of land are devoted to the purposes of agriculture, and between five and six thousand acres are devoted to the study and uses of forestry. This academy is probably the best specimen which Germany affords of the combined agricultural and forestral school. It has extensive and valuable collections. Its course of instruction extends to two and a half years. Its faculty consists of a director, nine professors and seven adjunct professors, two reviewers, and one assistant.

Professor Mathieu, of Nancy, describing this institution in the "Review of Woods and Forests," says: "The little kingdom of Würtemberg, with scarcely two million of inhabitants, has spared nothing in providing itself with whatever could contribute to the success of instruction or to the progress of science. This truly liberal spirit has led to the establishment of magnificent agricultural galleries, where we find collected, to the number of sixteen hundred, the various tools and machines employed in labors of the field; elegant rooms filled with forestral collections, implements, woods, and various products; cabinets in botany, zoölogy, mineralogy, and geology; instruments for use in studies of physics and geodesy; a station for experiments concerning woods, and another for meteorology. Its library numbers five thousand five hundred volumes, and its reading-room contains numerous periodicals in all languages, of which forty-nine are scientific,

agricultural, or forestral journals, and thirty-five are of the political, literary, or illustrated class."

The design of this academy is, in the words of another, "to impart a thorough, practical, and professional education to those who are to become the owners or managers of estates, and to farmers and foresters in public or private service, and to enable them to become champions of progress among their colleagues in business."

At the University of Tübingen, a chair of Agriculture and Forestry has existed since 1817.

The Polytechnic School at Carlsruhe, in Baden, has a department of forestry, with two professors. From thirty-five to forty students attend, of whom about one fifth are foreigners. The requirements for admission are as follows: Citizens of the state, who wish to enter the state forestry service, after attending a full course at the gymnasium, are admitted, and must pass through a course of four years, of which the first two are devoted to those fundamental and auxiliary studies which do not relate directly to forest-science, but which serve as a preparation for the remaining two years' studies, or the forest-course proper. Foreigners may attend the first two years or not, as they prefer. An age of seventeen years is required for admission. At the close of the second year the state students must pass an examination in natural philosophy and mathematics; but if they fail they are allowed one more trial. This examination entitles them to enter upon the last two years of special forest studies, in which they are taught agriculture, forest jurisprudence, and the higher mathematics, when they are again examined, and, if passed, are qualified for a place in the state service. The examination at the end of the first two years is by the professors of the polytechnic school, and the final examination by the forest directors, a person skilled in law, a professor of agriculture, a professor of forest management, and two professors of mathematics.

After passing all examinations, the candidate is assigned to the general district foresters as an assistant, to enable him to become practically acquainted with his duties, and he receives a tract of forest to manage. After six to ten years, according to the number waiting, he gets a position as general district forester. The number of forest districts in Baden at present is one hundred and ten, to about four of which appointments are made annually. The Forest Direction has its seat in Carlsruhe, and is composed of six members, who are inspectors.

The aids to instruction at this forest school are a valuable collection of objects pertaining to the subject, a chemical and physiological laboratory, to which a greenhouse is annexed, and a forest garden. The area of forests in Baden is 1,262,493 acres.

A school of forestry was established in connection with the University of Giessen, in Hesse-Darmstadt, in 1825, with two chairs of forestry and a course of three years. In 1831 this school was united

with the university, of which it now forms a department. The fundamental and auxiliary sciences, mathematics, natural sciences, chemistry, agriculture, law, etc., are taught by the professors of the university, while those studies that immediately relate to forestry come within the care of this special department.

The academic forest garden occupies six hectares, and Giessen and Schiffenberg forest-reviers in the neighborhood afford opportunities for practical study. The course of instruction extends through two years. Two excursions are made weekly, at which the subject of the lectures is practically illustrated, and the various operations of sylviculture are shown. Besides these, journeys of one or two weeks at a time are taken in summer, under the guidance of one of the teachers. The students of the forest institute enjoy the same rights as those of the university. The average attendance in the forestry department for several years past has been only about fifteen.

In the Grand-duchy of Saxe-Weimar is a forest institute, at Eisenach, with three professors and a course of instruction extending through three semesters. This institute was founded as a private school in 1808 by Oberforstrath König, at Rhula, but was made a state institution in 1830.

The Ducal Polytechnic School of Brunswick, founded in 1745 by Duke Charles I, and the first polytechnic school ever established, has a department of forestry.

In addition to these forest schools of the first order, as they may be termed, are subordinate schools at Weihmstephan and at Lichtenhof, near Nuremberg, besides numerous academies and private schools in which the principles of forestry are taught. Many forestry associations also, in one way or another, encourage the study of this science.

When we consider the limited territory of Germany, as compared with our own country, one can not take even this cursory observation of its forest schools without having the conviction impressed upon him that forestry is there regarded as a subject of the first importance, and that it has interests and relations which are very much if not altogether overlooked by us.

France has an eminent forest school at Nancy, which was established more than fifty years ago, and has a director and ten professors. It is designed to prepare agents for the state forest service, and foresters for the management of forests belonging to communes and public establishments. The number of pupils admitted is regulated by the wants of the administration from time to time. During the last fifty years, the school has graduated about a thousand men. In addition to those admitted to be trained for the public service, a certain number are admitted who are called *externes*. Great Britain, which has no school of forestry of her own, sends annually to Nancy from five to ten pupils to be trained for the management of her forests in India, and in the South African and other colonies.

The course of instruction at Nancy covers two years, and is very much like that at the German schools.

Another school, called the school of Forest Guards, at Barres, was established in 1865, by the Director-General of Forests, on what had been the estate of an eminent arboriculturist, M. Vilmorin. It has been reorganized recently and its plan has been extended.

An Agronomic Institute has been established lately at the Conservatory of Arts and Trades at Paris, having for its object the advancement of agriculture. It has fifteen professors, several of whom will be instructors of forestry in some of its branches. In addition to the instruction in forestry thus given, the French forestry administration is accustomed to send out agents to instruct classes in forestry at several of the agricultural schools. There are also inferior forest schools for the education of subaltern foresters at Grenoble and Villers-Cotterets.

The Austrian Empire is second only to Germany in the abundance and character of its forest schools and in the general interest taken in the subject of forestry. At the head of the Austrian schools stands the Imperial High School of Agriculture and Forestry at Vienna. This was founded by a royal decree of 1872, upon the basis of a reorganized forest school originally established at Mariabrunn, near Vienna, at the entrance of the beautiful Wienerwald. The school occupied an old monastery, and in it were gathered the amplest apparatus for study, including very fine museums and collections. By the decree of 1872 this school was united with the Agricultural College of Vienna, and the two now constitute one school in two sections. The agricultural section was opened in 1872, the forest section in 1875. The consolidated institution is designed to give the best instruction both in agriculture and forestry. The course of instruction extends over three years. Two classes of students are admitted : the ordinary, who must bring a certificate that they have completed a course at a gymnasium or upper real-school, or a department school of equal rank ; and the extraordinary, who must have sufficient preparatory training at least to enable them to understand the lectures, and who must have reached the age of seventeen years. The latter class are also obliged to pay tuition fees and can not receive the state stipends of which the ordinary pupils may avail themselves.

What are called secondary schools of forestry are established at Weisswasser in Bohemia, Eulenberg in Moravia, and at Lemberg in Galicia. These schools are formed on the German model. The course of instruction embraces two years. The requirements for admission are attendance for one year at a lower real-school or gymnasium, and in some cases a year's forest practice besides. Tuition is practically free.

There are also schools of forestry in Hungary. One is the Royal Hungarian Mining and Forest Academy at Schemnitz, which has been

developed from a School of Mines established as long ago as 1765. A forest institute was begun in 1807. Reorganizations have frequently taken place, until now the course of instruction is divided into six classes, two of which relate to forestry and forest engineering. The whole course is arranged for four years. From a memorial volume published recently, and soon after the celebration of the first centennial of the academy, it appears that it has graduated 5,373 pupils. The average annual attendance in recent years has been about 150.

Other schools of a lower grade, having a course of instruction of only one year in extent, are established at Aggsbach, in Lower Austria, and at Wildalpen, in Styria.

The Austro-Hungarian Empire has also many societies, which, though not schools of forestry, have a more or less direct relation to that subject and do much to promote it. Such are the Forest Society of the Tyrol, the Forestry Association of Manhartsburg, in Lower Austria, the Vienna Joint Stock Company for Forestry, the Forestry Company of Styria and Carinthia, the Association of Moravia and Bohemia, the Society of Western Galicia, and several others. In Croatia is a School of Agriculture and Forestry, with five professors, and a course of study of three years.

The Federal Union of the Swiss Cantons established a Polytechnic School at Zürich in 1855, in which a school of forestry forms the fifth division of instruction. The course of teaching extends to two years and a half. The separate cantons also make provision for elementary instruction in the science and art of forestry ; and still further provision is made for the teaching of the subject. As different states or kingdoms have a common interest in the navigation of a river which flows through their territories, and will rightly insist upon its being unimpeded, so it has been found by the cantons that they often have a common interest in the preservation of forests which may be situated in separate cantons, because their effects reach far beyond their particular locality. One canton might be more harmed by the destruction of a forest belonging to another canton than that canton itself. Accordingly, through the influence of the Swiss Forestry Association and the help of others acting with them, the Federal Constitution was amended in 1873, by the adoption of an article declaring that "the Federal Union has the right of supervising structures for the protection of watercourses and of the forest police in the mountain-regions." In the exercise of this right, the Union in 1876 enacted a comprehensive law, embodied in thirty-one distinct articles, relating to the high surveillance of the Confederation over the police of forests in the elevated regions.

For the more effectual carrying out of this law, provision was made in the same year for holding what may be called forest institutes, in the several cantons, during two months every year. At these institutes practical instruction is given in forestry, little if any attention being

bestowed on theories. The course of instruction embraces the following subjects, and we give the schedule, as suggesting what perhaps may be profitably done in this country at present, and while waiting for the establishment of fully endowed forest schools.

1. Forest surveys ; the marking out of woodlands ; measurement and calculation of small areas, as also of the trunks of trees, linear distances, etc. ; estimation of single trees and parcels of forest, as to quantity and value ; making of forest roads ; means of shielding forests against avalanches and small slides.

2. Study of the kinds of wood and of injurious herbs that should be known by sub-foresters.

3. Elementary study of the soil, and of the relations between different kinds of soils, and of the nature of different tracts of land.

4. Indispensable ideas of climatology and meteorology.

5. Cultivation and management of forests.

6. The information most important to sub-foresters concerning the working of forests, forest police and protection, and book-keeping.

7. The number of pupils shall not exceed thirty.

The applicants must be at least eighteen years of age, and must pass an examination in the primary studies as taught at the best schools ; and, if, at the end of the course of instruction, they are approved, they receive a certificate which puts them in the way of an appointment to the care of the high forests of which the Confederation has assumed the control, or of the forests still managed by the cantons separately, or by other corporations.

The teachers of these institutes are appointed by the cantons, subject to the approval of the Federal authority, but they are paid from the general treasury.

Italy, which has suffered greatly from the removal of her forests, and has taken action similar to that of the Swiss Confederation for their control, has an Institute of Forestry in the vale of Vallombrosa. It is situated in a noble wood of firs, high upon the slope of the Apennines, near the source of the Arno, where it puts to good use an old convent. In its plan of instruction the institute at Vallombrosa is much like that at Nancy.

Distinguished as Sweden is for her interest in education, statistics showing that at the present time only three per cent. of her criminals even are without school-training, we should expect that she would not be behind other countries in the matter of forestral instruction ; nor is she. A competent observer tells us that of late years "strenuous and successful endeavors have been made to introduce into the management of the forests the latest improvements adopted in Germany and France, and to regulate the national forest economy in accordance with the most advanced forest science of the day." The system of instruction established embraces a Forest Institute at Stockholm, which, in the

language of the royal ordinance for its management, "has for its end to educate able forest managers by free instruction"; subordinate to this, a system of district forest schools, of which the same ordinance says, "The aim of these forest schools is, through gratis instruction, to form good foresters"; and, finally, the common schools, together with private elementary schools of forestry, aided to some extent by the Government.

The Forest Institute at Stockholm ranks with the best forest schools of Europe. Its course of instruction and its management are so nearly like those in use at Nancy, at Neustadt-Eberswalde, and elsewhere, that we need not speak of them in detail.

The district forest schools are established at suitable points in the public forests. They are under the oversight of the Forest Bureau, and each under the visitation of the forest inspector in whose district of service the school is situated. Each forest school is presided over by a president, who is at the same time the teacher of the school, with a forest overseer as his assistant. The course of instruction embraces one full year, at the end of which the pupils have a public examination. In 1874 there were seven schools of this kind. There were alse thirteen private elementary schools of forestry, supported in part by government aid. It is also a noticeable feature of the system of education in Sweden that horticulture and tree-planting are taught in the Falk schools, or common schools. From the report of 1873 we find that in that year 59,860 pupils received such instruction. The same ratio would give 600,000 pupils for the United States.

Spain and Portugal, ranking lowest almost of all European countries in the proportion of their forest area to their total surface, the one having, on the authority of Reutzsch, 5·52, and the other 4·40 per cent., are yet not without their forest schools. A School of Forest Engineers was established in 1846, at Villaviciosa, not far from Madrid. In 1869 it was transferred to San Lorenzo del Escurial. It is under the direction of the Minister of Agriculture. Is has a director, nine professors, and two assistants. The course of instruction extends to three years.

An Agricultural Institute was founded at Lisbon in 1852. It was reorganized in 1865 as the General Institute of Agriculture. The course of instruction embraces rural engineering, sylviculture, agronomy, forest engineering, and veterinary medicine. The corps of instruction consists of ten professors and five substitutes, as they are called. The institute is well furnished with grounds, cabinets, and collections adapted to give practical instruction in the studies taught.

Denmark and Finland also have their schools of forestry, the one at Copenhagen, under the title of the Royal Veterinary and Agricultural High School, and the other at Evois.

Russia has several schools scattered throughout her vast territory.

For although her forests, particularly in the northern portion, seem inexhaustible, yet even among these the waste by accidental and designed burnings has at length shown the necessity of care and economy in forestry management. The forests of Russia have been swept off year by year by fires until portions of the country are suffering in a change of climate and in other respects as the consequence. The Volga is diminished in volume ; navigation is becoming more difficult ; fuel is getting scarce ; and the services of those trained in forest schools are needed in Russia almost as much as they are in Italy or Spain.

The Agronomic Institute at St. Petersburg is designed to give the best education in both agriculture and sylviculture, and is organized for this purpose in two sections. Those admitted to it must have finished a course of instruction at some gymnasium. It has one hundred and fifty students in the forestry section, a three years' course of study, and graduates annually about forty pupils.

The Agricultural and Forestral Academy at Petrovsk, near Moscow, founded in 1865, is similar in character and course of instruction to the institute at St. Petersburg. In 1872 it had three hundred and thirty-three pupils in attendance.

About fifty miles from St. Petersburg is the forest school of Lissino, a school of the second class, whose graduates receive the rank of forest conductors. The course of studies is of a practical character, and is of three years in extent.*

* This sketch gives a partial idea of the importance that is attached to forestry in countries whose age and experience have carried them beyond the stage of wasteful expenditure of resources in wood through which we are passing, to the point where necessity compels them to do all that is possible to make amends for their former recklessness, and to endeavor by every means to restore what they have lost. The trees are recognized as one of man's most valuable inheritances—with which his fortunes, public and private, are intimately associated ; and no interest in state or nation is paramount to that of having them preserved and properly cared for. The sources of information in regard to forestry and forest schools are of course as yet chiefly foreign. J. Croumbie Brown, of Haddington, England, for some time Government botanist at the Cape of Good Hope, has published several volumes bearing more or less directly on the subject. Hon. C. C. Andrews, late Minister to Sweden and Norway, has made a valuable report to the Department of State on the forests and forest-culture of Sweden. A report on forests and forestry, in connection with the International Exhibition at Vienna, in 1873, has also been made by John A. Warder, one of our commissioners. A voluminous report upon forestry has also been made, under the direction of the Commissioner of Agriculture, in pursuance of an act of Congress of 1876, by Franklin B. Hough, which contains a large amount of valuable information. We have drawn from these, in addition to the numerous French and German publications on forestry, for the facts here given in regard to forest schools.

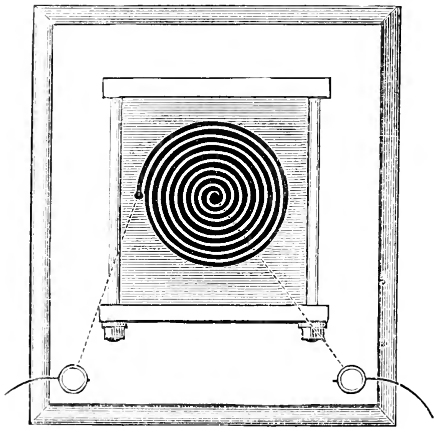
PRODUCTION OF SOUND BY RADIANT ENERGY.*

By ALEXANDER GRAHAM BELL.

AT the time of my communication to the American Association † the loudest effects obtained were produced by the use of selenium, arranged in a cell of suitable construction, and placed in a galvanic circuit with a telephone. Upon allowing an intermittent beam of sunlight to fall upon the selenium, a musical tone of great intensity was produced from the telephone connected with it.

But the selenium was very inconstant in its action. It was rarely, if ever, found to be the case that two pieces of selenium (even of the same stick) yielded the same results under identical circumstances of annealing, etc. While in Europe last autumn, Dr. Chichester Bell, of University College, London, suggested to me that this inconstancy of result might be due to chemical impurities in the selenium used. Dr. Bell has since visited my laboratory in Washington, and has made a chemical examination of the various samples of selenium I had collected from different parts of the world. As I understand it to be his intention to publish the results of this analysis very soon, I shall make no further mention of his investigation than to state that he has found sulphur, iron, lead, and arsenic in the so-called "selenium," with traces of organic matter; that a quantitative examination has revealed the fact that sulphur constitutes nearly one per cent. of the whole mass; and that when these impurities are eliminated the selenium appears to be more constant in its action and more sensitive to light.

Fig. 7.



Professor W. G. Adams ‡ has shown that tellurium, like selenium, has its electrical resistance affected by light, and we have attempted to utilize this substance in place of selenium. The arrangement of cell (shown in Fig. 7) was constructed for this purpose in the early

* Continued from page 197.

† "Proceedings of American Association for the Advancement of Science," August 27, 1880; see, also, "American Journal of Science," vol. xx, p. 305; "Journal of the American Electrical Society," vol. iii, p. 3; "Journal of the Society of Telegraph Engineers and Electricians," vol. ix, p. 404; "Annales de Chimie et de Physique," vol. xxi.

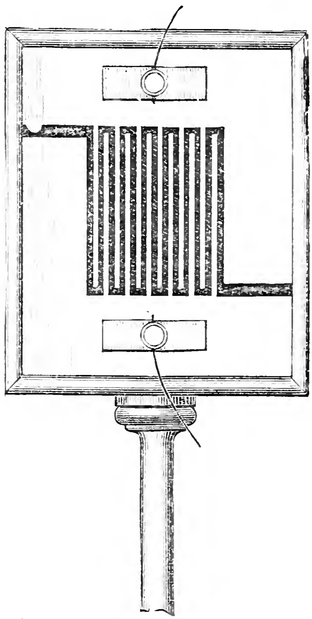
‡ "Proceedings of the Royal Society," vol. xxiv, p. 163.

part of 1880 ; but we failed at that time to obtain any indications of sensitiveness with a reflecting galvanometer. We have since found, however, that when this tellurium spiral is connected in circuit with a galvanic battery and telephone, and exposed to the action of an intermittent beam of sunlight, a distinct musical tone is produced by the telephone. The audible effect is much increased by placing the tellurium cell with the battery in the primary circuit of an induction-coil, and placing the telephone in the secondary circuit.

The enormously high resistance of selenium and the extremely low resistance of tellurium suggested the thought that an alloy of these two substances might possess intermediate electrical properties. We have accordingly mixed together selenium and tellurium in different proportions, and, while we do not feel warranted at the present time in making definite statements concerning the results, I may say that such alloys have proved to be sensitive to the action of light.

It occurred to Mr. Tainter, before my return to Washington last January, that the very great molecular disturbance produced in lampblack by the action of intermittent sunlight should produce a corresponding disturbance in an electric current passed through it, in which case lampblack could be employed in place of selenium in an electrical receiver. This has turned out to be the case, and the importance of the discovery is very great, especially when we consider the expense of such rare substances as selenium and tellurium.

Fig. 8.



The form of lampblack cell we have found most effective is shown in Fig. 8. Silver is deposited upon a plate of glass, and a zigzag line is then scratched through the film, as shown, dividing the silver surface into two portions insulated from one another, having the form of two combs with interlocking teeth.

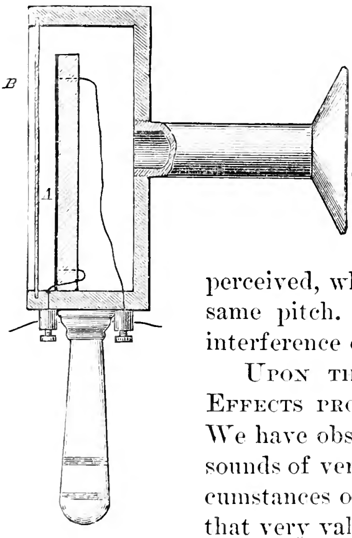
Each comb is attached to a screw-cup, so that the cell can be placed in an electrical circuit when required. The surface is then smoked until a good film of lampblack is obtained, filling the interstices between the teeth of the silver combs. When the lampblack cell is connected with a telephone and galvanic battery, and exposed to the influence of an intermittent beam of sunlight, a loud musical tone is produced by the telephone. This result seems to be due rather to the physical condition than to the nature of the conducting material employed, as metals in a spongy condition produce similar effects. For

instance, when an electrical current is passed through spongy platinum while it is exposed to intermittent sunlight, a distinct musical tone is produced by a telephone in the same circuit. In all such cases the effect is increased by the use of an induction-coil; and the sensitive cells can be employed for the reproduction of articulate speech, as well as for the production of musical sounds.

We have also found that loud sounds are produced from lampblack by passing through it an intermittent electrical current; and that it can be used as a telephonic receiver for the reproduction of articulate speech by electrical means.

A convenient mode of arranging a lampblack cell for experimental purposes is shown in Fig. 9. When an intermittent current is passed through the lampblack (A), or when an intermittent beam of sunlight falls upon it through the glass plate (B), a loud musical tone can be heard by applying the ear to the hearing-tube (C). When the light and the electrical current act simultaneously, two musical tones are perceived, which produce beats when nearly of the same pitch. By proper arrangements a complete interference of sound can undoubtedly be produced.

Fig. 9.



Upon the Measurement of the Sonorous Effects produced by Different Substances.—We have observed that different substances produce sounds of very different intensities under similar circumstances of experiment, and it has appeared to us that very valuable information might be obtained if we could measure the audible effects produced. For this purpose we have constructed several different forms of apparatus for studying the effects, but, as our researches are not yet complete, I shall confine myself to a simple description of some of the forms of apparatus we have devised.

When a beam of light is brought to a focus by means of a lens, the beam diverging from the focal point becomes weaker as the distance increases in a calculable degree. Hence, if we can determine the distances from the focal point at which two different substances emit sounds of equal intensity, we can calculate their relative sonorous powers.

Preliminary experiments were made by Mr. Tainter, during my absence in Europe, to ascertain the distance from the focal point of a lens at which the sound produced by a substance became inaudible. A few of the results obtained will show the enormous differences existing between different substances in this respect.

DISTANCE FROM FOCAL POINT OF LENS AT WHICH SOUNDS BECOME INAUDIBLE WITH DIFFERENT SUBSTANCES.

		Metres.
Zinc diaphragm (polished)		1·51
Hard-rubber diaphragm		1·90
Tin-foil "		2·00
Telephone "	(japanned iron)	2·15
Zinc "	(unpolished)	2·15
White silk,	(in receiver shown in Fig. 1.)	3·10
White worsted,	" " "	4·01
Yellow worsted,	" " "	4·06
Yellow silk,	" " "	4·13
White cotton-wool,	" " "	4·38
Green silk,	" " "	4·52
Blue worsted,	" " "	4·69
Purple silk,	" " "	4·82
Brown silk,	" " "	5·02
Black silk,	" " "	5·21
Red silk,	" " "	5·24
Black worsted,	" " "	6·50
Lampblack. In receiver the limit of audibility could not be determined, on account of want of space. Sound perfectly audible at a distance of		10·00

Mr. Tainter was convinced from these experiments that this field of research promised valuable results, and he at once devised an apparatus for studying the effects, which he described to me upon my return from Europe. The apparatus has since been constructed, and I take great pleasure in showing it to you to-day.

1. A beam of light is received by two similar lenses (A B, Fig. 10), which bring the light to a focus on either side of the interrupting disk (C). The two substances, whose sonorous powers are to be compared, are placed in the receiving vessels (D E) (so arranged as to expose equal surfaces to the action of the beam) which communicate, by flexible tubes (F G) of equal length, with the common hearing-tube (H). The receivers (D E) are placed upon slides, which can be moved along the graduated supports (I K). The beams of light passing through the interrupting disk (C) are alternately cut off by the swinging of a pendulum (L). Thus a musical tone is produced alternately from the substance in D and from that in E. One of the receivers is kept at a constant point upon its scale, and the other receiver is moved toward or from the focus of its beam until the ear decides that the sounds produced from D and E are of equal intensity. The relative positions of the receivers are then noted.

2. Another method of investigation is based upon the production of an interference of sound, and the apparatus employed is shown in Fig. 11. The interrupter consists of a tuning-fork (A, Fig. 11, *a*), which is kept in continuous vibration by means of an electro-magnet (B).

A powerful beam of light is brought to a focus between the prongs

of the tuning-fork (A), and the passage of the beam is more or less obstructed by the vibration of the opaque screens (C D) carried by the prongs of the fork.

As the tuning-fork (A) produces a sound by its own vibration, it is placed at a sufficient distance away to be inaudible through the air, and a system of lenses is employed for the purpose of bringing the undulating beam of light to the receiving lens (E) with as little loss as possible. The two receivers (F G) are attached to slides (H I) which move upon opposite sides of the axis of the beam, and the receivers are connected by flexible tubes of unequal length (K L) communicating with the common hearing-tube (M).

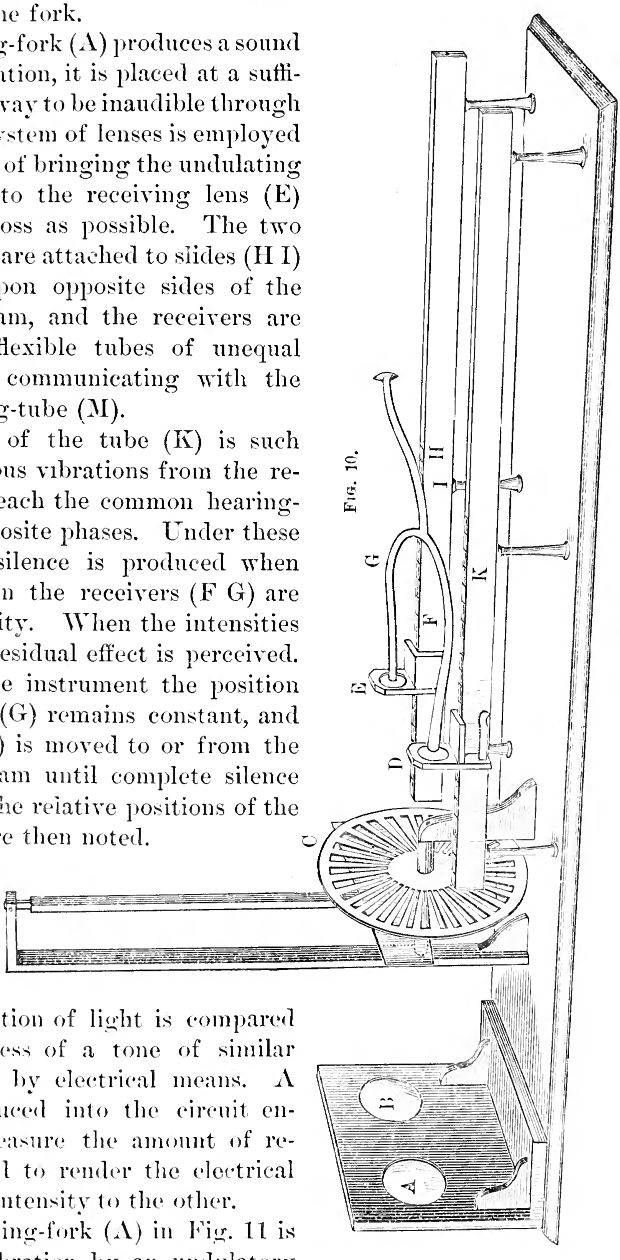


Fig. 10.

The length of the tube (K) is such that the sonorous vibrations from the receivers (F G) reach the common hearing-tube (M) in opposite phases. Under these circumstances silence is produced when the vibrations in the receivers (F G) are of equal intensity. When the intensities are unequal, a residual effect is perceived. In operating the instrument the position of the receiver (G) remains constant, and the receiver (F) is moved to or from the focus of the beam until complete silence is produced. The relative positions of the two receivers are then noted.

3. Another mode is as follows: The loudness of a musical tone produced by the action of light is compared with the loudness of a tone of similar pitch produced by electrical means. A rheostat introduced into the circuit enables us to measure the amount of resistance required to render the electrical sound equal in intensity to the other.

4. If the tuning-fork (A) in Fig. 11 is thrown into vibration by an undulatory instead of an intermittent current passed through the electro-magnet (B), it is probable that a musical tone, electrically produced in the re-

ceiver (F) by the action of the same current, would be found capable of extinguishing the effect produced in the receiver (G) by the action of the undulatory beam of light, in which case it should be possible to establish an acoustic balance between the effects produced by light and electricity by introducing sufficient resistance into the electric circuit.

FIG. 11.

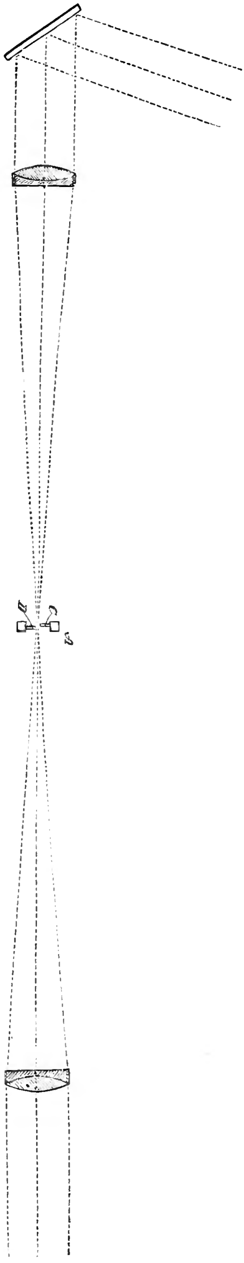
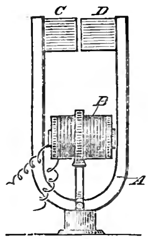
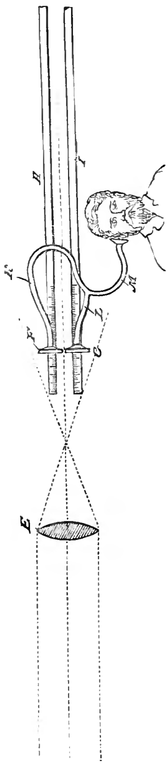


FIG. 11, *a*.





UPON THE NATURE OF THE RAYS THAT PRODUCE SONOROUS EFFECTS IN DIFFERENT SUBSTANCES.—In my paper read before the American Association last August, and in the present paper, I have used the word "light" in its usual rather than its scientific sense, and I have not hitherto attempted to discriminate the effects produced by the different constituents of ordinary light—the thermal, luminous, and actinic rays. I find, however, that the adoption of the word "photophone" by Mr. Tainter and myself has led to the assumption that we believed the audible effects discovered by us to be due entirely to the action of luminous rays. The meaning we have uniformly attached to the words "photophone" and "light" will be obvious from the following passage, quoted from my Boston paper:

> Although effects are produced, as above shown, by forms of radiant energy, which are invisible, we have named the apparatus for the production and reproduction of sound in this way the "photophone," *because an ordinary beam of light contains the rays which are operative.*

To avoid in future any misunderstandings upon this point, we have decided to adopt the term "*radiophone*," proposed by M.

Mercadier, as a general term signifying an apparatus for the production of sound by any form of radiant energy, limiting the words *thermophone*, *photophone*, and *actinophone* to apparatus for the production of sound by thermal, luminous, or actinic rays respectively.

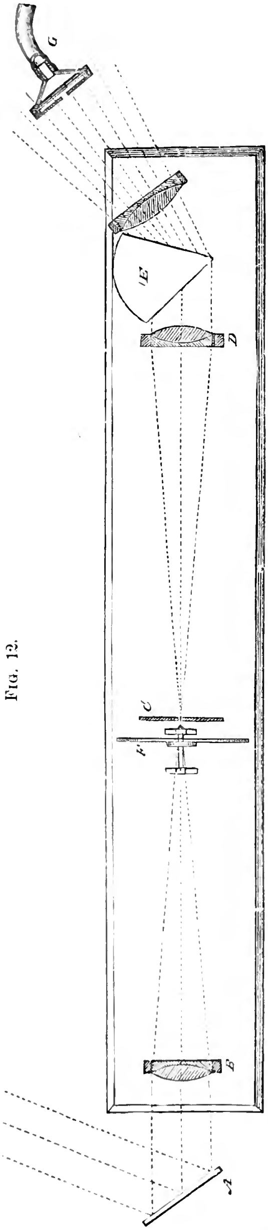


FIG. 12.

M. Mercadier, in the course of his researches in radiophony, passed an intermittent beam from an electric lamp through a prism, and then examined the audible effects produced in different parts of the spectrum ("Comptes Rendus," December 6, 1880).

We have repeated this experiment, using the sun as our source of radiation, and have obtained results somewhat different from those noted by M. Mercadier.

A beam of sunlight was reflected from a heliostat (A, Fig. 12) through an achromatic lens (B), so as to form an image of the sun upon the slit (C).

The beam then passed through another achromatic lens (D), and through a bisulphide-of-carbon prism (E), forming a spectrum of great intensity, which, when focused upon a screen, was found to be sufficiently pure to show the principal absorption lines of the solar spectrum.

The disk-interrupter (F) was then turned with sufficient rapidity to produce from five to six hundred interruptions of the light per second, and the spectrum was explored with the receiver (G), which was so arranged that the lampblack surface exposed was limited by a slit, as shown.

Under these circumstances sounds were obtained in every part of the visible spectrum, excepting the extreme half of the violet, as well as in the ultra-red. A continuous increase in the loudness of the sound was observed upon moving the receiver (G) gradually from the violet into the ultra-red. The point of maximum sound lay very far out in the ultra-red. Beyond this point the sound began to decrease, and then stopped so suddenly that a very slight motion of the receiver (G) made all the difference between almost maximum sound and complete silence.

2. The lampblacked wire gauze was then removed, and the in-

terior of the receiver (G) was filled with red worsted. Upon exploring the spectrum as before, entirely different results were obtained. The maximum effect was produced in the green at that part where the red worsted appeared to be black. On either side of this point the sound gradually died away, becoming inaudible on the one side in the middle of the indigo, and on the other at a short distance outside the edge of the red.

3. Upon substituting green silk for red worsted, the limits of audition appeared to be the middle of the blue and a point a short distance out in the ultra-red—maximum in the red.

4. Some hard-rubber shavings were now placed in the receiver (G). The limits of audibility appeared to be, on the one hand, the junction of the green and blue, and, on the other, the outside edge of the red—maximum in the yellow. Mr. Tainter thought he could hear a little way into the ultra-red, and to his ear the maximum was about the junction of the red and orange.

5. A test-tube containing the vapor of sulphuric ether was then substituted for the receiver (G). Commencing at the violet end, the test-tube was gradually moved down the spectrum and out into the ultra-red without audible effect, but, when a certain point far out in the ultra-red was reached, a distinct musical tone suddenly made its appearance, which disappeared as suddenly on moving the test-tube a very little farther on.

6. Upon exploring the spectrum with a test-tube containing the vapor of iodine, the limits of audibility appeared to be the middle of the red and the junction of the blue and indigo—maximum in the green.

7. A test-tube containing peroxide of nitrogen was substituted for that containing iodine. Distinct sounds were obtained in all parts of the visible spectrum, but no sounds were observed in the ultra-red.

The maximum effect seemed to me to be in the blue. The sounds were well marked in all parts of the violet, and I even fancied that the audible effect extended a little way into the ultra-violet, but of this I can not be certain. Upon examining the absorption spectrum of peroxide of nitrogen it was at once observed that the maximum sound was produced in that part of the spectrum where the greatest number of absorption lines made their appearance.

8. The spectrum was now explored by a selenium cell, and the audible effects were observed by means of a telephone in the same galvanic circuit with the cell. The maximum effect was produced in the red. The audible effect extended a little way into the ultra-red on the one hand and up as high as the middle of the violet on the other.

Although the experiments so far made can only be considered as preliminary to others of a more refined nature, I think we are warranted in concluding that *the nature of the rays that produce sonorous effects in different substances depends upon the nature of the substances*

that are exposed to the beam, and that the sounds are in every case due to those rays of the spectrum that are absorbed by the body.

THE SPECTROPHONE.—Our experiments upon the range of audibility of different substances in the spectrum have led us to the construction of a new instrument for use in spectrum analysis, which was described and exhibited to the Philosophical Society of Washington last Saturday.* The eye-piece of a spectroscope is removed, and sensitive substances are placed in the focal point of the instrument behind an opaque diaphragm containing a slit. These substances are put in communication with the ear by means of a hearing-tube, and thus the instrument is converted into a veritable "spectrophone," like that shown in Fig. 13.

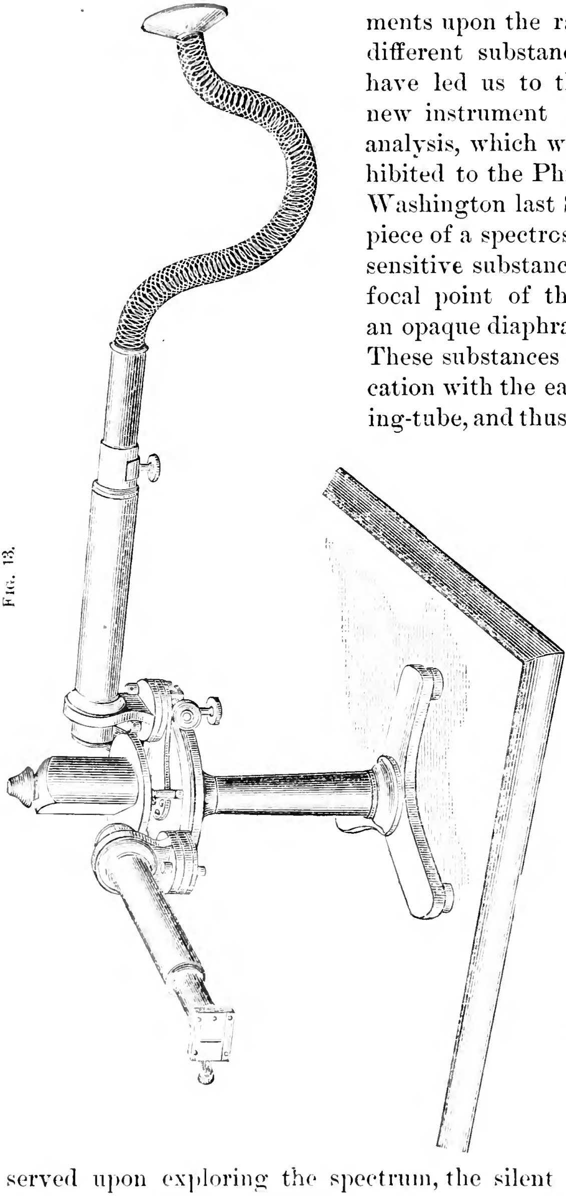


FIG. 13.

Suppose we smoke the interior of our spectrophonic receiver, and fill the cavity with peroxide of nitrogen gas. We have then a combination that gives us good sounds in all parts of the spectrum (visible and invisible), except the ultra-violet. Now, pass a rapidly-interrupted beam of light through some substance whose absorption spectrum is to be investigated, and bands of sound and silence are observed upon exploring the spectrum, the silent positions corresponding to the absorption bands. Of course, the ear can not for one moment compete with the eye in the examination of the visible part of the spectrum; but in the invisible part beyond the red, where

* "Proceedings of the Philosophical Society" of Washington, April 16, 1881.

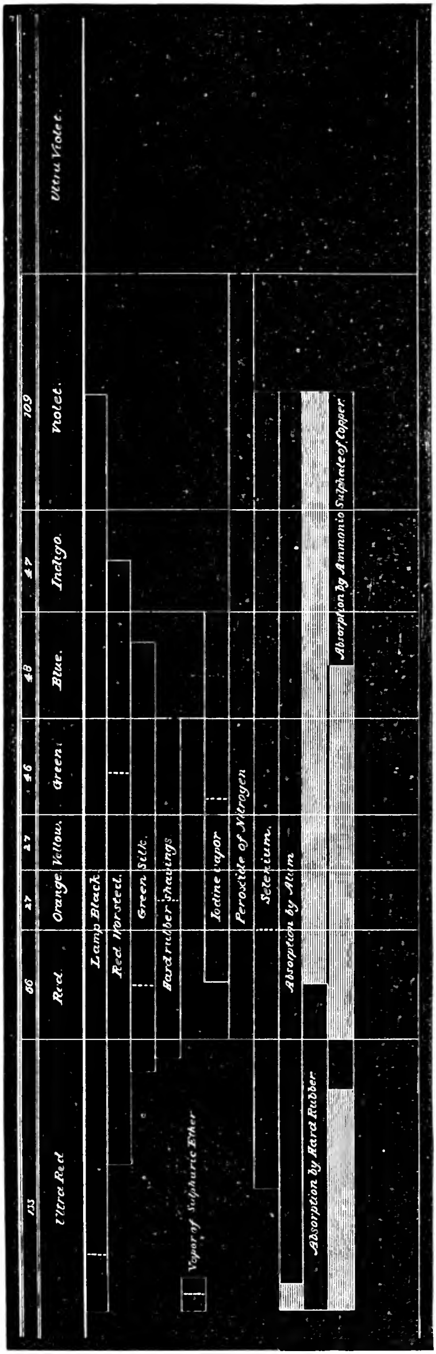


Fig. 14.

the eye is useless, the ear is invaluable. In working in this region of the spectrum, lampblack alone may be used in the spectrophonic receiver. Indeed, the sounds produced by this substance in the ultra-red are so well marked as to constitute our instrument a most reliable and convenient substitute for the thermopile. A few experiments that have been made may be interesting.

1. The interrupted beam was filtered through a saturated solution of alum.

Result: The range of audibility in the ultra-red was slightly reduced by the absorption of a narrow band of the rays of lowest refrangibility. The sounds in the visible part of the spectrum seemed to be unaffected.

2. A thin sheet of hard rubber was interposed in the path of the beam.

Result: Well-marked sounds in every part of the ultra-red. No sounds in the visible part of the spectrum, excepting the extreme half of the red.

These experiments reveal the cause of the curious fact alluded to in my paper read before the American Association last August — that sounds were heard from selenium when the beam was filtered through both hard rubber and alum at the same time. (See table of results in Fig. 14.)

3. A solution of ammonia-sulphate of copper was tried.

Result: When placed in the path of the beam, the spectrum disappeared, with the exception of the blue and violet end. To the eye the spectrum was thus reduced to a single broad band of blue-violet light. To the ear, however, the spectrum revealed itself as two bands of sound, with a broad space of silence between. The invisible rays transmitted constituted a narrow band just outside the red.

I think I have said enough to convince you of the value of this new method of examination, but I do not wish you to understand that we look upon our results as by any means complete. It is often more interesting to observe the first totterings of a child than to watch the firm tread of a full-grown man, and I feel that *our* first footsteps in this new field of science may have more of interest to you than the fuller results of mature research. This must be my excuse for having dwelt so long upon the details of incomplete experiments.

I recognize the fact that the spectrophone must ever remain a mere adjunct to the spectroscope, but I anticipate that it has a wide and independent field of usefulness in the investigation of absorption spectra in the ultra-red.

PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

SLEEP.

"Children, stinted in their sleep, are never wide-awake."—PESTALOZZI.

THE vital processes of man, like those of all his fellow-creatures, are partly controlled by automatic tendencies. Some functions of our internal economy are too important to be trusted to the caprices of human volition; breathing, eating, drinking, and even love, are only semi-voluntary actions; and during a period varying from one fourth to two fifths of each solar day the conscious activity of the senses undergoes a complete suspense: the cerebral workshop is closed for repairs, and the abused or exhausted body commits its organism into the healing hands of Nature. Under favorable conditions eight hours of undisturbed sleep would almost suffice to counteract the physiological mischief of the sixteen waking hours. During sleep the organ of consciousness is at rest, and the energies of the system seem to be concentrated on the function of nutrition and the renewal of the vital energy in general; sleep promotes digestion, repairs the waste of the muscular tissue, favors the process of cutaneous excretion, and renews the vigor of the mental faculties.

The amount of sleep required by man is generally proportionate to the waste of vital strength, whether by muscular exertion, mental

activity (or emotion), or by the process of rapid assimilation, as during the first years of growth and during the recovery from an exhausting disease. The weight of a new-born child increases more rapidly than that of a eupeptic adult, enjoying a liberal diet after a period of starvation, and, though an infant is incapable of forming abstract ideas, we need not doubt that the variety of new and bewildering impressions must overtask its little sensorium in a few hours. Nurslings should therefore be permitted to sleep to their full satisfaction; weakly babies, especially, need sleep more than food, and it is the safest plan never to disturb a child's slumber while the regularity of his breathing indicates the healthfulness of his repose; there is little danger of his "oversleeping" himself in a moderately warmed, well-ventilated room. Never mind about meal-times: hunger will awaken him at the right moment, or teach him to make up for lost time. Three or four nursings in the twenty-four hours are enough; Dr. C. E. Page, who has made the problem of infant diet his special study, believes that fifty per cent. of the enormous number of children dying under two years of age are killed by being coaxed to guzzle till they are hopelessly diseased with fatty degeneration.*

The healthfulness of village-children is partly due to the tranquillity of their slumber in the comfortable nooks of a quiet homestead, or in the shade of a leafy tree, while their parents are at work in a way rather incompatible with the habit of fondling the baby all night. In houses where there is plenty of room, the nursery and the infant's dormitory ought to be two separate apartments: the play-room can not be too sunny; for the bedroom a shady and sequestered location is, on the whole, preferable. Next to out-door exercise, silence and a subdued light are the best hypnotics. But under no circumstances should insomnia be overcome by cradling or narcotics. Stupefaction is not slumber. The lethargy induced by rocking and cradling is akin to the drowsy torpor of a sea-sick passenger, and the opium-doctor might as well benumb his patient by a whack on the head. The morbid sleeplessness of children may be owing to several causes which can be generally recognized by the symptoms of their *modus operandi*; impatient turning from side to side, as if in a vain attempt to obtain a much-needed repose, means that the room is too stuffy or too warm; long wakefulness, combined with squalling-fits and petulant movements, indicates acidity in the stomach (overfeeding, or too much "soothing-sirup")—let the little kicker exercise his muscle on the floor; in malignant cases, skip a meal or two, or give water instead of

* "The only wonder is that any infant lives sixty days from birth. Fed before birth but three times a day he is after birth subjected to ten or twenty meals in the twenty-four hours, until chronic dyspepsia or some acute disease interferes. . . . So far from admitting a possible error in advising three meals only, I am convinced that, for a hand-fed baby especially, two would often be better than three."—("How to feed a Baby to make it healthy and happy," p. 55.)

milk. After weathering an attack of croup, children often lie motionless on their backs with a peculiar glassy stare of their wide-open eyes. Leave them alone; instinct teaches them to assuage the distress of their lungs by slow and deep respirations; rest and a half-open window will do them more good than medicine.

Healthful infants—i. e., under rational management the great plurality—can soon be taught to transact their public business at seasonable hours, or at least to abstain from midnight serenades. If mothers would make it a rule to do all their nursing and fondling in the daytime, their little revivalists would soon learn to associate darkness with the idea of silence and slumber. Habit will do wonders in such things. Captain Barclay and several American pedestrians learned to take their half-hour naps as a traveler snatches a hasty lunch, and many old soldiers develop a faculty of going off to sleep, as it were, at the word of command, the moment their shoulders touch the guard-house bunk. The two drowsiest years of my life I passed at an old-style boarding-school, where teachers and pupils were limited to seven hours of sleep, after nine hours of study, besides written exercises and special recitations, and where sixty or seventy of us had to sleep in a large hall; and I do not believe that the last flickering of our five-minutes candle was ever witnessed by a pair of more than half-open eyes.

But that same faculty of sleeping and waking at short notice may be utilized for the purpose of taking little naps whenever opportunity offers—in the last half-hour of the noontide recess, or during the Buncombe interacts of a protracted session. The inhabitants of all intertropical countries make the time of repose a movable festival, and during the dog-days of our torrid summers it would clearly be the best plan to imitate their example. "Children must not sleep in the daytime," says a by-law of our time-dishonored Koran of domestic superstitions; and, not satisfied with keeping our little ones at school during the drowsy afternoons of the summer solstice, we increase their misery by stuffing them at the very noon of the hottest hours with a mass of greasy (i. e., heat-producing and soporific) food. An hour after the end of a long, sultry day comes the cool night-wind, heaven's own blessing for all who hunger and thirst after fresh air; but no, "Night-air is injurious"; besides, Mrs. Grundy objects to promenades after dark, so the children are driven to their suffocating, unventilated bedrooms, not to sleep but to swelter, till toward midnight, when drowsiness subsides into a sort of lethargy which yields only to broad daylight, three or four hours after sunrise; "So much the better," says the fashionable mother, who has passed the night at an ice-cream *ridotto*, "and morning air isn't healthy, either; most dangerous to leave the house before the dew is off the grass."

Only the curse of pessimism, our woful distrust of our natural instincts, can explain such absurdities. The parched palate's petition

for a cooling liquid is not plainer than the brain's craving for rest and slumber when a high temperature adds its somniferous tendency to the drowsy influence of a full meal. On warm summer days all Nature indulges in a noontide nap; I have walked through tropical forests that were as silent under the rays of a vertical sun as a Norwegian pine-grove in the dead of a polar night; nor would it be easy to name a single animal that does not appear sleepy after meals. At noon leaf-trees throw their densest shade; even butterflies seek the penetralia of the foliage, and lizards cling lazily to the dark side of the lower branches; every school-teacher knows that children feel the drowsy spell of the afternoon sun; why should they alone be hurt by yielding to its promptings? Either postpone the principal meal to the end of the day, or increase the noontide recess to at least three hours, so as to leave time for a digestive *siesta*.

In midsummer all mammals (squirrels, perhaps, excepted) become semi-nocturnal: deer and llamas pasture the moonlit mountain-meadows; bears, badgers, and the larger species of monkeys are wide-awake; buffaloes wander *en masse* to the next drinking-place; and the step-children of Nature, the starved lazzaroni of Southern Europe, forget their misery if they can procure a fiddle or a guitar. The moonlit streets of the Mexican cities swarm with merry children, but north of the Rio Grande not a decent lad is seen out-doors after sundown; Luna has to seek her Endymions in the tropics, though our summer nights are often as glorious as the *noches serenas* of southern Andalusia. And what would our hardy forefathers have said about our dread of the morning dew? How many thousands of hunters and soldiers have slept in the open fields, and how many times did we *wade* through the dew-drenched brambles of the Ardennes, my little brother and I, to see the sun rise, and breathe the mountain wind, at the only hour when the air is both fragrant and cool, inspiring thoughts which music can only awaken for a fleeting moment!—if such hours are mortiferous, there can not be a more agreeable way of ending what our latter-day epicures are pleased to call life.

What harm can there be in dividing our daily portion of sleep? Birds and beasts do it, the founders of the most ascetic orders of Spanish monks allowed it, and our summer months are certainly as warm as those of Southern Europe. People who are so anxious to improve the shining hours for business purposes had much better curtail the number of their meals; take a vote among the juvenile operatives of a cotton-factory, and ten to one that a large majority would gladly postpone, or even renounce, their dinner for the privilege of sleeping an hour or two between 1 and 3 P. M. A Belgian silk-manufacturer, who had spent his own boyhood at the loom, told me that he could never find it in his heart to discharge a factory-child for dozing over its work.

Necessity may compel individuals to compromise such matters. If

I had to work or teach all day, I would not eat a crumb between breakfast and supper, and pass the dinner-hour under a shade-tree; but parents who can afford to educate their children at home should give them either an all-summer vacation or a half-afternoon recess—let them rest from twelve till three, or sleep if they prefer; in the evening, do not send them to bed till they are really tired, and till the night-wind has revitalized the air of their bedrooms; but make them rise with the sun—if they are drowsy they will go to bed earlier the next evening. There is no danger of a child's—especially a boy's—oversleeping himself, unless the hardships of his waking hours are so intolerable that oblivion becomes a blessing; but it can do no harm to make the health-giving morning hour as attractive as possible: provide some out-door amusement, a prize foot-race, a butterfly-hunt, or gathering windfalls in the apple-orchard; if the desire for longer sleep can outweigh such inducements, there must be something wrong—plethorific diet, probably, or over-study. The requisite amount of sleep depends on temperament and occupation as well as on age; with children under ten, however, too much indulgence would be an error on the safer side: let them choose their allowance between eight and ten hours; in after-years, seven hours should be the minimum, nine the maximum for *healthy* children; sickly ones ought to have *carte blanche*, both as to quantum and time of repose; consumptives, especially, need all the rest they can get. Profound sleep in a cool, quiet retreat is Nature's own specific for all wasting diseases, a panacea without price and money.

Nothing can be more injudicious than to stint children in their sleep with a view of gaining a few hours for study. "That plan," says Pestalozzi, "defeats its own purpose, for such children are never wide-awake; you can keep them out of bed, but you can not prevent them from dozing with their eyes open. A wide-awake boy will learn more in one hour than a day-dreamer in ten."

Habitual deficiency of sleep will undermine the strongest constitution; headache, throbbing, and feverish heat are the precursors of graver evils, unless a temporary loss of mental power compels an armistice with outraged Nature. King Alfred, Spinoza, Kepler, Victor Alfieri, Madame de Staël, and Frederick Schiller killed themselves with restless study; Beethoven and Charles Dickens, too, probably prepaid the debt of Nature by their habit of fighting fatigue with strong coffee. Sleeplessness may lead to chronic hypochondria, and even to idiocy; without their long vigils, the monks of the Thebais and the fathers of the Alexandrian Church could hardly have written such stupendous nonsense. It is a curious fact that compulsory wakefulness combined with mental activity often induces a state of morbid insomnia, an absolute inability to obtain the sleep which it was at first so difficult to resist. In such cases, the only remedy is fresh air and a complete change of occupation. During sleep the brain is in a com-

paratively bloodless condition;* a hot head and throbbing temples are unfavorable to repose, and it has been suggested that insomnia might be counteracted by a hot foot-bath, chafing the arms and legs, or any similar operation that would divert the blood from the head toward the extremities, and thus tend to diminish the activity of the cerebral circulation. Listening to distant music or the ripple of a river-current has also a wonderful hypnotic effect, the repetition of monotonous sounds, or, indeed, of any sensorial impression, seems more favorable to repose than their entire absence. The philosopher Kant assures us that he could obtain sleep in a paroxysm of gout by resolutely fixing his attention on some abstruse ethical or mathematical problem, but remarks that the success of that method depends upon the laboriousness of the mental process; the mind, as it were, takes refuge in sleep as the alternative of drudging at a wearisome task. Robert Burton, too, gives a number of similar recipes, besides a list of wondrous medicinal compounds to be swallowed or inhaled *ad horam somni*, but in ordinary cases it is better to try the effects of out-door exercise, before resorting to dormouse-fat,† theological text-books, or other desperate remedies.

Being naturally a sound and long sleeper has been ranked among the surest prognostics of a long life, and sleep after a wasting disease as the most certain symptom of recovery. Most brain-workers are subject to occasional fits of insomnia, but the faculty of sustaining health and vigor upon a very small allowance of sleep is generally a concomitant of mental inferiority, or at least inactivity. The most intelligent animals, dogs and monkeys, sleep the longest; stupid brutes merely stretch their legs, their inert brain requires no rest; a cow never sleeps in the proper sense of the word. Mirabeau, Goethe, and James Quin often slumbered for twelve or fourteen hours successively, while Leopold I, of Austria, and Charles IV, of Spain, the heartless and brainless bigots, could content themselves with five hours of sleep out of the twenty-four, and their prototype, the Emperor Justinian, often even with *one*.—(Gibbon's "Rome," vol. vii, p. 406.)

Heinrich Heine wonders why Jehovah did not square his account with our wicked forefathers by punishing them in their sleep, instead of compromising their innocent progeny. Dietetic sins often avenge themselves in that way; blutwurst, sauerkraut, or short-cakes with

* Dr. Caldwell records a case of a woman at Montpellier, who "had lost part of her skull (from disease), the brain and part of its membranes lying bare. When she was in a deep and sound sleep, the brain lay in the skull almost motionless; when she was dreaming, it became elevated; and, when she awoke, it became suffused with blood and seemed inclined to rise through the cranial aperture."—("Psychological Journal," vol. v, p. 74.)

† "Anoint the soles of the feet with the fat of a dormouse, the teeth with ear-wax of a dog, swine's gall, oil of nunaphar, henbane," etc.—("Correctors of Accidents to procure Sleep," "Anatomy of Melancholy," p. 414.)

pork-fritters, generally result in apocalyptic visions, and an eel-pie for supper is a reliable receipt for a first-class nightmare. Vivid dreams, *per se*, however, are by no means a morbid symptom; on the contrary, the scenes of the slumber-drama are most lively and lifelike in the happiest years of childhood; and I remember a time when I longed for the bed-hour, in anticipation of a pleasant dream-land excursion. Children are apt to relate their trance adventures, and I would encourage the habit; dreams, as the elder Pliny already observes, may often afford a suggestive insight into the ethical condition of the mind; also into the condition of the stomach. Melodramatic incidents indicate the presence of irritating ingesta, and the least attempt at clairvoyance calls for out-door exercise and an aperient diet. A South-German feather-bed is a Trophonian cave; the difficulty of turning from side to side crowds the brain with alarming phantasms, and the excessive warmth of the thing itself is apt to affect the imagination. The best bed is, indeed, a hard, broad mattress, or a well-stuffed straw tick, and, for reasons I have stated in the chapter on "In-door Life," a woolen blanket over a linen bed-sheet is preferable to a quilt. Those who find it uncomfortable to sleep in an absolutely horizontal position should slightly raise the head-end of the bedstead rather than use a thick bolster. A thick pillow bends the head upon the breast, or keeps the neck in a position that aggravates the distress of respiratory difficulties. Woven-wire mattresses recommend themselves by their cleanliness and durability; their elastic qualities alone would hardly justify a great expense, though luxury has even devised an "hydrostatic bed," a trough of water with a tegument of caoutchouc. History records the name of the Sybarite who "cried aloud because a leaflet of his flower-mattress got crumpled"; and Chevalier Luckner, the Russian Lucullus, built himself an air-pillow bed on noiseless wheels, that could be turned by a hand-lever, in order to move the sleeping-car from or toward the stove, the aphelion and perihelion being determined by the state of the out-door atmosphere. Such chevaliers deserve the penance of Ezekiel (iv, 3–6), who had to lie three hundred and ninety days on his left side for the iniquity of the house of Israel, and forty days extra for the iniquity of the house of Judah. A weary head needs no air-cushions, with noiseless wheel-attachments; brakesmen take their intermittent naps on the hard caboose-bunk of a rumbling freight-train; and the log of the Royal Sovereign records that, during the heat of the battle of the Nile, some of the over-fatigued boys fell asleep upon the deck.

The habit of going to sleep at fixed hours can overcome the tortures of neuralgia, and some practical stoics have manifested a not less astonishing command over their mental emotions; Napoleon I slept soundly on the eve of the battle he knew to be his last chance, like Mohammed II before his last neck-or-nothing assault upon the ramparts of Constantinople. Army-life can acquaint a man with

strange beds, as well as bedfellows. Skobeleff's troopers had to sleep in dug-outs on the woodless ridges of the Balkan; and during Ney's retreat from Moscow, the commander himself had once to pass a night in a root-house, where a few rotten boards and a bundle of straw formed his only protection against a raging snow-storm.

But "roughing it" teaches some useful lessons, and soldiers and hunters often learn by experience that sleep under such circumstances depends upon the possibility of *getting the feet warm;* rain in the face, or even a wet overcoat, is less anti-hypnotic than chilled toes. In a trapper's bivouac the sleepers generally lie in a circle around the camp-fire, with their feet toward the glowing embers, and the Swiss mountaineers use foot-sacks—long socks of a felt-like stuff, and wide enough to leave room for a lot of dry leaves, besides two or three pairs of stockings. Both methods are practical applications of Dr. Caldwell's theory that a decrease of the cerebral blood-circulation has a somniferous influence; in other words, that sleep can be promoted by warming the extremities of the body, and thus diverting the blood from the head.

In-doors, summer often reverses the problem; in the dog-days, when the amount of bedclothing has to be reduced to a minimum, the main point is to cool the head by lowering the temperature of the bedroom. Open windows, a hard, smooth mattress, linen bed-sheets, and a light supper will generally answer the purpose; in the lower latitudes, George Combe recommends glazed brick floors, frequent sprinklings, and in very hot nights a tub with ice. And why not? The Turkish residents of Damascus pass the summer nights in the *yeyirman* or fountain-hall of their cool houses, and the garrison soldiers of San Juan d'Ulloa deem it a special privilege to sleep on the floating wharf, exposed to the spray and the fitful swell of the Gulf-tide.

In the West Indies and the Mississippi Valley, mosquito-bars are a sad necessity, but all sensible people should be glad that the French canopy-beds are going out of fashion. The French are right, though, in making children over ten years sleep alone; it is one of the rare instances of an etiquette law being supported by a valid reason. To those who can afford it, Dr. Franklin recommends even two beds per individual, and in sweltering summer nights it is certainly a blessing to be able to leave a hot bed for a cool one; in the large family guest-chambers of a German hotel, sleepless travelers can thus change the beds like relay-horses. The builders of the old English country-seats seem to have made it a rule to have the houses face due south, with few or no windows on the north side, and in such buildings the east windows would make the best bedroom fronts, both on account of the evening shade and the monitory morning sun. In our Northwestern Territories, where the thermometer ranges from 90° above zero to 45° below, it would be no bad plan to vary the location of the bedcham-

ber with the change of the season, but, as a general rule, the dormitory should be the coolest room in the house—i. e., the nearest to the north side, and the farthest from the kitchen.

THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

By HERBERT SPENCER.

VIII.—CONSULTATIVE BODIES.

TWO parts of the primitive triune political structure have, in the last two chapters, been dealt with separately; or, to speak strictly, the first has been considered as independent of the second, and again, the second as independent of the first: incidentally noting its relations to the third. Here we have to treat of the two in combination. Instead of observing how from the chief, little above the rest, there is, under certain conditions, evolved the absolute ruler, entirely subordinating the select few and the many; and instead of observing how, under other conditions, the select few become an oligarchy tolerating no supreme man, and keeping the multitude in subjection, we have now to observe the cases in which there is established a coöperation between the first and the second.

After chieftainship has become settled, the chief continues to have sundry reasons for acting in concert with his head-men. It is needful to conciliate them; it is needful to get their advice and willing assistance; and, in serious matters, it is desirable to divide responsibility with them. Hence the prevalence of a consultative assembly. In Samoa, "the chief of the village and the heads of families formed, and still form, the legislative body of the place." Among the Foolahs, "before undertaking anything important or declaring war, the king [of Rabbah] is obliged to summon a council of Mallams and the principal people." Of the Mandingo states we read that, "in all affairs of importance, the king calls an assembly of the principal men, or elders, by whose counsels he is directed." And such cases might be multiplied indefinitely.

That we may fully understand the essential nature of this institution, and that we may see why, as it evolves, it assumes the distinctive characters it does, we must once more go back to the beginning.

Evidence, coming from many peoples in all times, shows that the consultative body is, at the outset, nothing more than a council of war. It is in the open-air meeting of armed men that the cluster of leaders is first seen performing that deliberative function in respect of military measures which is afterward extended to other measures. Long after

its deliberations have become more general in their scope, there survive traces of this origin.

In Rome, where the king was above all things the general, and where the senators, as the heads of clans, were, at the outset, war-chiefs, the burgesses were habitually, when called together, addressed as "spear-men": there survived the title which was naturally given to them when they were present as listeners at war-councils. So, during later days in Italy, when the small republics grew up. Describing the assembling of "citizens at the sound of a great bell, to concert together the means of their common defense," Sismondi says, "This meeting of all the men of the state capable of bearing arms was called a Parliament." Concerning the gatherings of the Poles in early times we read: "Such assemblies, before the establishment of a senate, and while the kings were limited in power, were of frequent occurrence, and . . . were attended by all who bore arms"; and at a later stage "the *comitia paludata*, which assembled during an interregnum, consisted of the whole body of nobles, who attended in the open plain, armed and equipped as if for battle." In Hungary, too, up to the beginning of the sixteenth century, "les seigneurs, à cheval et armés de pied en cap comme pour aller en guerre, se réunissaient dans le champ de courses de Rakos, près de Pesth, et là discutaient en plain air les affaires publiques." Again, "the supreme political council is the nation in arms," says Stubbs of the primitive Germans; and though, during the Merovingian period, the popular power declined, yet, "under Chlodovech and his immediate successors, the people assembled in arms had a real participation in the resolutions of the king." Even now the custom of going weapon in hand is maintained where the primitive political form remains. "To the present day," writes M. Laveleye, "the inhabitants of the Outer Rhodes of Appenzell come to the general assembly, one year at Hundwyl and the other at Trogen, each carrying in his hand an old sword or ancient rapier of the middle ages." Mr. Freeman, too, was witness to a like annual gathering in Uri, where the inhabitants assemble in arms to elect their chief magistrate and to deliberate.

It may, indeed, be alleged that in early, unsettled times the carrying of arms by each freeman was needful for personal safety, especially when a place of meeting very far from his home had to be reached. But there is evidence that, though this continued to be a cause for assembling in arms, it was not by itself a sufficient cause. While we read of the ancient Scandinavians that "all freemen capable of bearing arms were admitted" to the national assembly, and that, after his election from "among the descendants of the sacred stock," "the new sovereign was elevated amid the clash of arms and the shouts of the multitude," we also read that "nobody, not even the king or his champions, were allowed to come armed to the assizes."

Even apart from such evidence, there is ample reason to infer that the council of war originated the consultative body, and gave outlines to its structure. Defense against enemies was everywhere the need which originally prompted joint deliberation. For other purposes individual action, or action in small parties, might suffice; but for insuring the general safety combined action of the whole horde or tribe was necessary; and to secure this combined action must have been the first motive for a political gathering. Moreover, certain constitutional traits of early assemblies, among the civilized, point to councils of war as having initiated them. If we ask what must happen when, in a tribe, the predominant few debate military measures in presence of the many, the reply is that, in the absence of a developed political organization, the assent of the many to any decision must be obtained before it can be acted upon; and the like must at first happen when many tribes are united. As Gibbon says of the Diet of the Tartars, formed of chiefs of tribes and their martial trains, "the monarch who reviews the strength, must consult the inclination, of an armed people." Even if, under such conditions, the predominant few could impose their will upon the many, armed like themselves, it would clearly be impolitic to do so, since success in war would be endangered by dissension. Hence would arise the usage of putting to the surrounding mass of armed men the question whether they agreed to the course which the council of chiefs had decided upon. There would grow up a form such as that which had become established for governmental purposes at large among the early Romans, whose king or general asked the assembled burgesses or "spear-men" whether they approved of the proposal made; or like that ascribed by Tacitus to the primitive Germans, who, now with murmurs and now with brandishing of spears, rejected or accepted the suggestions of their leaders. Moreover, there would naturally come just that restricted expression of popular opinion which we are told of. The Roman burgesses were allowed to answer only "Yes" or "No" to any question put to them; and this is exactly the simple answer which the chief and head warriors would require from the rest of the warriors when war or peace had to be determined upon. A kindred restriction existed among the Spartans. In addition to the senate and coördinate kings, there was "an Ekklesia, or public assembly of citizens, convened for the purpose of approving or rejecting propositions submitted to them, with little or no liberty of discussion"—a usage quite explicable if we assume that in the Homeric Agora, from which the Spartan constitution descended, the assembled chiefs had to gain the assent of their surrounding followers before important actions could be undertaken.

Concluding, then, that war originates political deliberation, and that the select body which especially carries on this deliberation first takes shape on occasions when the public safety has to be provided

for, we shall be prepared the better to understand the traits which characterize the consultative body in later stages of its development.

Already we have seen that at the outset the militant class was of necessity the land-owning class. In the savage tribe there are no owners of the tract occupied, save the warriors who use it in common for hunting. During pastoral life, good regions for cattle-feeding are jointly held against intruders by force of arms. And, where the agricultural stage has been reached, communal possession, family possession, and individual possession, have from time to time to be defended by the sword. Hence, as was shown, the fact that in early stages the bearing of arms and the holding of land habitually go together.

While, as among hunting-peoples, land continues to be held in common, the contrasts which arise between the few and the many are such only as result from actual or supposed personal superiority of one kind or other. It is true that, as pointed out, differences of wealth, in the shape of chattels, boats, slaves, etc., cause some class-differentiations; and that thus, even before private land-owning begins, quantity of possessions aids in distinguishing the governing from the governed. When the pastoral state is arrived at and the patriarchal type established, such ownership as there is vests in the eldest son of the eldest; or if, as Sir Henry Maine says, he is to be considered trustee for the group, still his trusteeship joins with his military headship in giving him supremacy. At a later stage, when lands come to be occupied by settled families and communities, and land-ownership gains definiteness, this union of traits in each head of a group becomes more marked; and, as was shown when treating of the differentiation of nobles from freemen, several influences conspire to give the eldest son of the eldest superiority in extent of landed possessions, as well as in degree of power. Nor is this fundamental relation changed when a nobility of service replaces a nobility of birth, and when, as presently happens, the adherents of a conquering invader are rewarded by portions of the subjugated territory, granted on condition of continued military service. Throughout, the tendency continues to be for the class of military superiors to be identical with the class of large land-owners.

It follows, then, that, beginning with the general assemblage of armed freemen, all of them holding land individually or in groups, whose council of leaders, deliberating in presence of the rest, are distinguished only as being the most capable warriors, there will, through frequent wars and progressing consolidations, be produced a state in which this council of leaders becomes further distinguished from the rest by the larger possessions, and consequent greater powers, of its members. Becoming more and more contrasted with the general mass of armed freemen, the consultative body will tend gradually to subordinate it, and, eventually separating itself, will become independent.

The growth of this temporary council of war, in which the king, acting as general, summons to give their advice the leaders of his forces, into the permanent consultative body in which the king, in his capacity of ruler, presides over the deliberations of the same men on public affairs at large, is exemplified in various parts of the world. The consultative body is everywhere composed of minor chiefs, or heads of clans, or feudal lords, in whom the military and civil rule of local groups is habitually joined with wide possessions; and the examples frequently exhibit this composition on both a small and a large scale—both locally and generally. A rude and early form of the arrangement is shown in Africa. Among the Caffres "every chief chooses from among his most wealthy subjects five or six, who act as counselors to him. . . . The great council of the king is composed of the chiefs of particular kraals." A Bechuana tribe "generally includes a number of towns or villages, each having its distinct head, under whom there are a number of subordinate chiefs," who "all acknowledge the supremacy of the principal one. His power, though very great and in some instances despotic, is, nevertheless, controlled by the minor chiefs, who, in their *pichos* or *pitshos*, their parliament or public meetings, use the greatest plainness of speech in exposing what they consider culpable or lax in his government." Of the Wanyamwezi, Burton says that the Sultan is "surrounded by a council, varying from two to a score of chiefs and elders. . . . His authority is circumscribed by a rude balance of power; the chiefs around him can probably bring as many warriors into the field as he can." Similarly in Ashantee. "The caboceers and captains . . . claim to be heard on all questions relating to war and foreign politics. Such matters are considered in a general assembly, and the king sometimes finds it prudent to yield to the views and urgent representations of the majority." From the ancient American states, too, instances may be cited. In Mexico "general assemblies were presided over by the king every eighty days. They came to these meetings from all parts of the country"; and then we read further that the highest rank of nobility, the Teuctli, "took precedence of all others in the senate, both in the order of sitting and voting," showing what was the composition of the senate. It was so, too, with the Central Americans of Vera Paz: "Though the supreme rule was exercised by a king, there were inferior lords as his coadjutors, who mostly were titled lords and vassals; they formed the royal council, . . . and joined the king in his palace as often as they were called upon." Turning to Europe, mention may first be made of ancient Poland. Originally formed of independent tribes, "each governed by its own *kniaz*, or judge, whom age or reputed wisdom had raised to that dignity," and each led in war by a temporary *voivod* or captain, these tribes had, in the course of that compounding and recompounding which wars produced, differentiated into classes of nobles and serfs, over whom was an elected king. Of the organi-

zation which existed before the king lost his power, we are told that—

Though each of these palatines, bishops, and barons, could thus advise his sovereign, the formation of a regular senate was slow, and completed only when experience had proved its utility. At first, the only subjects on which the monarch deliberated with his barons related to war; what he originally granted through courtesy, or through diffidence in himself, or with a view to lessen his responsibility in case of failure, *they* eventually claimed as a right.

So, too, during internal wars and wars against Rome, the primitive Germanic tribes, once semi-nomadic and but slightly organized, passing through the stage in which armed chiefs and freemen periodically assembled for deliberations on war and other matters, evolved a kindred structure. In Charlemagne's time, at the great assembly of the year—

The dukes, counts, bishops, scabini, and centenaries—all who were connected with the government or the administration—were officially present; the great and small proprietors, the barons and gentry, were so in virtue of their fiefs, the freemen in virtue of their character as warriors, though undoubtedly there were few freemen obliged to bear arms not provided with some portion of landed property.

And then at a later period, as Hallam writes—

In all the German principalities a form of limited monarchy prevailed, reflecting, on a reduced scale, the general constitution of the empire. As the emperors shared their legislative sovereignty with the Diet, so all the princes who belonged to that assembly had their own provincial states, composed of their feudal vassals and of their mediate towns within their territory—

the mass of the rural population having thus ceased to possess power. Similarly during the later feudal period in France. An "ordinance of 1228, respecting the heretics of Languedoc, is rendered with the advice of our great men and prudhommes"; and one "of 1246, concerning levies and redemptions in Anjou and Maine," says that, "having called around us, at Orleans, the barons and great men of the said counties, and having held attentive counsel with them," etc.

To meet the probable criticism that no notice has been taken of the ecclesiastics usually included in the consultative body, it is needful to point out that due recognition of them does not involve any essential change in the account above given. Though modern usages lead us to think of the priest-class as distinct from the warrior-class, yet it was not originally distinct. With the truth that, habitually in militant societies, the king is at once commander-in-chief and high-priest, carrying out in both capacities the dictates of his deity, we may join the truth that the subordinate priest is usually a direct or indirect aider of the wars thus supposed to be divinely prompted. In illustration of the one truth may be cited the fact that, before going to war, Radama, King of Madagascar, "acting as priest as well as general, sacrificed a

cock and a heifer, and offered a prayer at the tomb of Andria-Masina, his most renowned ancestor." And in illustration of the other truth may be cited the fact that, among the Hebrews, whose priests accompanied the army to battle, we read of Samuel, a priest from childhood upward, as conveying to Saul God's command to "smite Amalek," and as having himself hewed Agag in pieces. More or less active participation in war by priests we everywhere find in savage and semi-civilized societies; as among the Dakotas, Mundrucus, Abipones, Khonds, whose priests decide on the time for war, or give the signal for attack; as among the Tahitians, whose priests "bore arms, and marched with the warriors to battle"; as among the Mexicans, whose priests, the habitual instigators of wars, accompanied their idols in front of the army, and "sacrificed the first-taken prisoners" at once; as among the ancient Egyptians, of whom we read that "the priest of a god was often a military or naval commander." And the naturalness of the connection, thus common in rude and in ancient societies, is shown by its revival in later societies, notwithstanding an adverse creed. After Christianity had passed out of its early extra-political stage into the stage in which it became a state religion, its priests, during actively militant periods, reacquired the primitive militant character. "By the middle of the eighth century [in France], regular military service on the part of the clergy was already fully developed." In the early feudal period, bishops, abbots, and priors, became feudal lords, with all the powers and responsibilities attaching to their positions: they had bodies of troops in their pay, took towns and fortresses, sustained sieges, led or sent troops in aid of kings. And Orderic, in 1094, describes the priests as leading their parishioners to battle, and the abbots their vassals. Though in recent times Church dignitaries do not actively participate in war, yet their advisatory function respecting it —often prompting rather than restraining—has not even now ceased, as among ourselves was lately shown in the vote of the bishops, who, with one exception, approved the invasion of Afghanistan.

That the consultative body habitually includes ecclesiastics, does not, therefore, conflict with the statement that, beginning as a war-council, it grows into a permanent assembly of minor military heads.

Under a different form there is here partially repeated what was set forth when treating of oligarchies: the difference arising from inclusion of the king as a coöperative factor. Moreover, much that was before said respecting the influence of war in narrowing oligarchies applies to that narrowing of the primitive consultative assembly by which there is produced from it a body of land-owning military nobles. But that consolidation of small societies into large ones effected by war brings other influences which join in working this result.

In early assemblies of men similarly armed it must happen that though the inferior many will recognize that authority of the superior

few which is due to their leaderships as warriors, to their clan-headships, or to their supposed supernatural descent, yet the superior few, conscious that they are no match for the inferior many in a physical contest, will be obliged to treat their opinions with some deference—will not be able completely to monopolize power. But as fast as there progresses that class-differentiation before described, and as fast as the superior few acquire better weapons than the inferior many, or, as among various ancient peoples, have war-chariots, or, as in mediæval Europe, wear coats of mail or plate-armor and are mounted on horses, they, feeling their advantage, will pay less respect to the opinions of the many. And the habit of ignoring their opinions will be followed by the habit of regarding any expression of their opinions as an impertinence.

This gradual usurpation will be furthered by the growth of those bodies of armed dependents with which the superior few surround themselves—mercenaries and others, who, while unconnected with the common freemen, are bound by fealty to their employers. These, too, with better weapons and defensive appliances than the mass, will be led to regard them with contempt, and to aid in subordinating them.

Not only on the occasions of general assemblies, but from day to day in their respective localities, the increasing power of the chiefs thus caused will tend to reduce the freemen more and more to the rank of dependents, and especially so where the military service of such nobles to their king is dispensed with or allowed to lapse, as happened in Denmark about the thirteenth century:

> The free peasantry, who were originally independent proprietors of the soil, and had an equal suffrage with the highest nobles in the land, were thus compelled to seek the protection of these powerful lords, and to come under vassalage to some neighboring Herremand or bishop or convent. The provincial diets, or Lands-Ting, were gradually superseded by the general national Parliament of the Dannehof, Adel-Ting, or Herredag; the latter being exclusively composed of the princes, prelates, and other great men of the kingdom. . . . As the influence of the peasantry had declined, while the burghers did not yet enjoy any share of political power, the constitution, although disjointed and fluctuating, was rapidly approaching the form it ultimately assumed—that of a feudal and sacerdotal oligarchy.

A further influence conducing to loss of power by the armed freemen and gain of power by the armed chiefs, who form the consultative body, follows that widening of the occupied area which goes along with the compounding and recompounding of societies. As Richter remarks of the Merovingian period: "Under Chlodovech and his immediate successors, the people assembled in arms had a real participation in the resolutions of the king. But, with the increasing size of the kingdom, the meeting of the entire people became impossible." Only those who lived near the appointed places could attend. Two

facts, one already given under another head, may be named as illustrating this effect: "The greatest national council in Madagascar is an assembly of the people of the capital and the heads of the provinces, districts, towns, villages," etc.; and, speaking of the English Witenagemot, Mr. Freeman says, "Sometimes we find direct mention of the presence of large and popular classes of men, as the citizens of London or Winchester": the implication in both cases being that all freemen had a right to attend, but that only those on the spot could readily avail themselves of the right. This cause for restriction, which is commented upon by Mr. Freeman, operates in several ways. The actual cost of a journey to the place fixed for the meeting, when a kingdom has become large, is too great to be borne by a man who owns but a few acres. Further, there is the indirect cost entailed by loss of time, which, to one who personally labors or superintends labor, is serious. Again, there is the danger, which in turbulent times is considerable, save to those who go with bodies of well-armed retainers. And obviously these deterrent causes must tell where, for the above reasons, the incentives to attend have become small.

Yet another cause coöperates. When the occupied area is large, and therefore the number inhabiting it great, an assembly of all the armed freemen, could they be gathered, would be disabled from taking part in the proceedings, both by its size and by its lack of organization. A multitude made of those who have come from scattered points over a wide country, mostly unknown to one another, unable to hold previous communication, and therefore without plans, as well as without leaders, can not cope with the relatively small but well-organized body of those having common ideas and acting in concert.

Nor should there be omitted the fact that when the causes above named have conspired to decrease the attendance of men in arms who live far off, and when there grows up the usage of summoning the more important among them, it naturally happens that in course of time the receipt of a summons becomes the authority for attendance, and the absence of a summons becomes equivalent to the absence of a right to attend.

Here, then, are several influences, all directly or indirectly consequent upon war, which join in differentiating the consultative body from the mass of armed freemen out of which it arises.

Given the ruler, and given the consultative body thus arising, there remains to ask, What are the causes of change in their relative powers? Always between these two authorities there must be a struggle—each trying to subordinate the other. Under what conditions, then, is the king enabled to override the consultative body; and under what conditions is the consultative body enabled to override the king?

Inevitably a belief in the superhuman nature of the king gives him an immense advantage in the contest for supremacy. If he is god-

descended, open opposition to his will by his advisers is out of the question; and members of his council, singly or in combination, dare do no more than tender humble advice. Moreover, if the line of succession is so settled that there rarely or never occur occasions on which the king has to be elected by the chief men, so that they have no opportunity of choosing one who will conform to their wishes, they are further debarred from maintaining any authority. Hence, habitually, we do not find consultative bodies having an independent *status* in the despotically governed countries of the East, ancient or modern. Though we read of the Egyptian king that "he appears to have been attended in war by the council of the thirty, composed apparently of privy councilors, scribes, and high officers of state," the implication is that the members of this council were functionaries, having such powers only as the king deputed to them. Similarly in Babylonia and Assyria, attendants and others who performed the duties of ministers and advisers to the god-descended rulers did not form established assemblies for deliberative purposes. In ancient Persia, too, there was a like condition. The hereditary king, almost sacred and bearing extravagant titles, though subject to some check from princes and nobles of royal blood who were leaders of the army, and who tendered advice, was not under the restraint of a constituted body of them. Throughout the history of Japan down to our own time a kindred state of things existed. The Daimios were required to be present at the capital during prescribed intervals, as a precaution against insubordination; but they were never, while there, called together to take any share in the government. And hereditary divine kingship, having this as its concomitant in Japan, has it likewise in China. We read that, "although there is nominally no deliberative or advisatory body in the Chinese Government, and nothing really analogous to a congress, parliament, or *tiers-état*, still necessity compels the Emperor to consult and advise with some of his officers." Nor does Europe fail to yield us evidence of like meaning. I do not refer only to the case of Russia, but more especially to the case of France during the time when monarchy had assumed its most absolute form. In the age when divines like Bossuet taught that "the King is accountable to no one, . . . the whole state is in him, and the will of the whole people is contained in his"—in the age when the King (Louis XIV), "imbued with the idea of his omnipotence and divine mission," "was regarded by his subjects with adoration"—he "had extinguished and absorbed even the minutest trace, idea, and recollection of all other authority except that which emanated from himself alone." Along with establishment of hereditary succession and acquirement of divine *prestige*, such power of the other estates as existed in early days had disappeared.

Conversely, there are cases showing that where the king has never had, or does not preserve, the *prestige* of supposed descent from a

god, and where he continues to be elective, the power of the consultative body is apt to override the royal power, and eventually to suppress it. The first to be named is that of Rome. Originally "the king convoked the senate when he pleased, and laid before it his questions; no senator might declare his opinion unasked; still less might the senate meet without being summoned." But here, where the king, though regarded as having divine approval, was not held to be of divine descent, and where, though usually nominated by a predecessor, he was sometimes practically elected by the senate and always submitted to the form of popular approval, the consultative body presently became supreme. "The senate had in course of time been converted, from a corporation intended merely to advise the magistrates, into a board commanding the magistrates, and self-governing." Afterward "the right of nominating and canceling senators, originally belonging to the magistrates, was withdrawn from them"; and, finally, "the irremovable character and life-tenure of the members of the ruling order, who obtained seat and vote, was definitely consolidated": the oligarchic constitution became pronounced. The history of Poland yields another example. After unions of simply-governed tribes had produced small states and generated a nobility, and after these small states had been united, there arose a kingship. At first elective, as kingships habitually are, this continued so—never became hereditary. On the occasion of each election out of the royal clan, there was an opportunity of choosing for king one whose character the turbulent nobles thought fittest for their own purposes; and hence it resulted that the power of the kingship decayed. Eventually—

> Of the three orders into which the state was divided, the king, though his authority had been anciently despotic, was the least important. His dignity was unaccompanied with power; he was merely the president of the senate, and the chief judge of the republic.

And then there is the instance furnished by Scandinavia, already named in another relation. Danish, Norwegian, and Swedish kings were originally elective; and, though, on sundry occasions, hereditary succession became for a time the usage, there were repeated lapses into the elective form, with the result that predominance was gained by the feudal chieftains and prelates forming the consultative body.

The second element in the triune political structure is thus, like the first, developed by militancy. By this the ruler is eventually separated from all below him; and by this the superior few become integrated into a deliberative body separated from the inferior many.

That the council of war, formed of leading warriors who debate in presence of their followers, is the germ out of which the consultative body arises, is implied by the survival of usages which show that a political gathering is originally a gathering of armed men. In har-

mony with this implication are such facts as that, after a comparatively settled state has been reached, the power of the assembled people is limited to accepting or rejecting the proposals made, and that the members of the consultative body, summoned by the ruler, who is also the general, give their opinions only when invited by him to do so.

Nor do we lack clews to the process by which the primitive war-council grows, consolidates, and separates itself. Within the warrior-class, which is also the land-owning class, war produces increasing differences of wealth, as well as increasing differences of *status;* so that, along with the compounding and recompounding of groups which war brings about, the military leaders come to be distinguished as large land-owners and local rulers. Hence, members of the consultative body become contrasted with the freemen at large, not only as leading warriors are contrasted with their followers, but, still more, as men of wealth and authority.

This increasing contrast between the second and third elements of the triune political body ends in separation when, in course of time, war consolidates large territories. Armed freemen scattered over a wide area are deterred from attending the periodic assemblies by cost of travel, by cost of time, by danger, and also by the experience that multitudes of men, unprepared and unorganized, are helpless in presence of an organized few, better armed and mounted, and with bands of retainers. So that, passing through a time during which only the armed freemen living near the place of meeting attend, there comes a time when even these, not being summoned, are considered as having no right to attend; and thus the consultative body becomes completely differentiated.

Changes in the relative powers of the ruler and the consultative body are determined by obvious causes. If the king retains or acquires the repute of supernatural origin or authority, and the law of hereditary succession is so settled as to exclude election, those who might else have formed a consultative body having coördinate power become simply appointed advisers. But, if the king has not the *prestige* of supposed sacred origin or commission, and continues to be elective, then the consultative body retains power, and is liable to become an oligarchy.

Of course, it is not alleged that all consultative bodies have arisen in the way described, or are constituted in like manner. Societies, broken up by wars or dissolved by revolutions, may preserve so little of their primitive organizations that there remain no classes of the kinds out of which such consultative bodies as those described arise. Or, as we see in our own colonies, societies may have been formed in ways which have not fostered classes of land-owning militant chiefs, and therefore do not furnish the elements out of which the consultative body, in its primitive shape, is composed. Under conditions of

these kinds the assemblies answering to them, so far as may be in position and function, are formed under the influence of tradition or example; and in default of men of the original kind are formed of others—generally, however, of those who, by position, seniority, or previous official experience, are more eminent than those forming popular assemblies. It is only to what may be called the normal consultative body which grows up during that compounding and recompounding of small societies into large ones which war effects that the foregoing description applies; and the senates, or superior chambers, which arise under later and more complex conditions, may be considered as homologous to them in function and composition so far only as the new conditions permit.

ON FRUITS AND SEEDS.*

By Sir JOHN LUBBOCK, F. R. S.

IN a very large number of cases the diffusion of seeds is effected by animals. To this class belong the fruits and berries. In them an outer fleshy portion becomes pulpy, and generally sweet, inclosing the seeds. It is remarkable that such fruits, in order, doubtless, to attract animals, are, like flowers, brightly colored—as, for instance, the cherry, currant, apple, peach, plum, strawberry, raspberry, and many others. This color, moreover, is not present in the unripe fruit, but is rapidly developed at maturity. In such cases the actual seed is generally protected by a dense, sometimes almost stony, covering, so that it escapes digestion, while its germination is perhaps hastened by the heat of the animal's body. It may be said that the skin of apple and pear pips is comparatively soft; but then they are imbedded in a stringy core, which is seldom eaten.

These colored fruits form a considerable part of the food of monkeys in the tropical regions of the earth, and we can, I think, hardly doubt that these animals are guided by the colors, just as we are, in selecting the ripe fruit. This has a curious bearing on an interesting question as to the power of distinguishing color possessed by our ancestors in bygone times. Magnus and Geiger, relying on the well-known fact that the ancient languages are poor in words for color, and that in the oldest books—as, for instance, in the Vedas, the Zend-Avesta, the Old Testament, and the writings of Homer and Hesiod—though, of course, the heavens are referred to over and over again, its blue color is never dwelt on, have argued that the ancients were very deficient in the power of distinguishing colors, and especially blue. In our own country Mr. Gladstone has lent the weight of his great

* Continued from page 171.

authority to the same conclusion. For my part I can not accept this view. There are, it seems to me, very strong reasons against it, into which I can not, of course, now enter; and, though I should rely mainly on other considerations, the colors of fruits are not, I think, without significance. If monkeys and apes could distinguish them, surely we may infer that even the most savage of men could do so too. Zeuxis would never have deceived the birds if he had not had a fair perception of color.

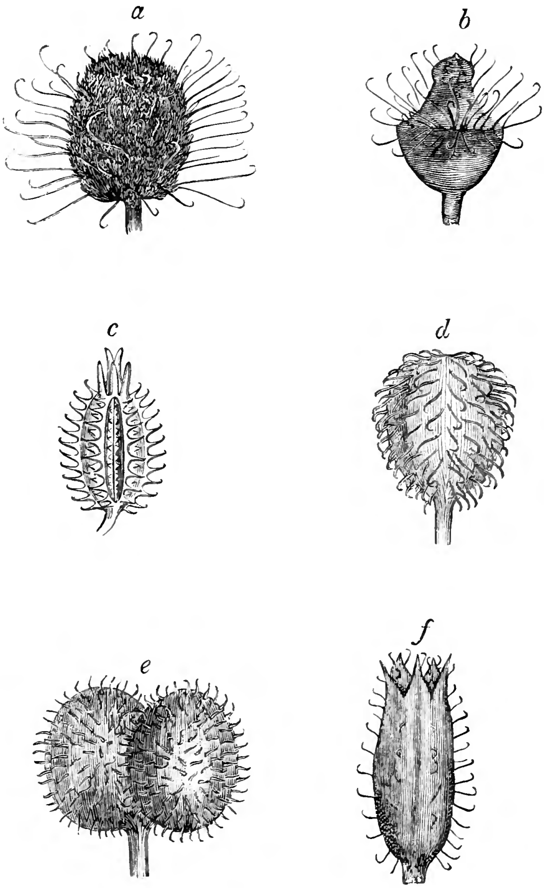


FIG. 14.—*a*, burdock (*Lappa*); *b*, agrimony (*Agrimonia*); *c*, bur parsley (*Caucalis*); *d*, enchanter's nightshade (*Circæa*); *e*, cleavers (*Galium*); *f*, forget-me-nots (*Myosotis*).

In these instances of colored fruits, the fleshy edible part more or less surrounds the true seeds; in others the actual seeds themselves become edible. In the former the edible part serves as a temptation to animals; in the latter it is stored up for the use of the plant itself. When, therefore, the seeds themselves are edible they are generally protected by more or less hard or bitter envelopes, for instance the

horse-chestnut, beech, Spanish chestnut, walnut, etc. That these seeds are used as food by squirrels and other animals is, however, by no means necessarily an evil to the plant, for the result is that they are often carried some distance and then dropped, or stored up and forgotten, so that in this way they get carried away from the parent tree.

In another class of instances animals, unconsciously or unwillingly, serve in the dispersion of seeds. These cases may be divided into two classes, those in which the fruits are provided with hooks, and those in which they are sticky. To the first class belong, among our common English plants, the burdock (*Lappa*, Fig. 14 *a*), agrimony (*Agrimonia*, Fig. 14 *b*); the bur parsley (*Caucalis*, Fig. 14 *c*); enchanter's nightshade (*Circæa*, Fig. 14 *d*); goose-grass or cleavers (*Galium*, Fig. 14 *e*), and some of the forget-me-nots (*Myosotis*, Fig. 14 *f*). The hooks, moreover, are so arranged as to promote the removal of the fruits. In all these species the hooks, though beautifully formed, are small; but in some foreign species they become truly formidable. Two of the most remarkable are represented on page 357—*Martynia proboscidea* (Fig. 15 *b*) and *Harpagophyton procumbens* (Fig. 15 *a*). Martynia is a plant of Louisiana, and if its fruits once get hold of an animal it is most difficult to remove them. Harpagophytum is a South African genus. The fruits are most formidable, and are said sometimes even to kill lions. They roll about over the dry plains, and, if they attach themselves to the skin, the wretched animal tries to tear them out, and sometimes getting them into his mouth perishes miserably.

The cases in which the diffusion of fruits and seeds is affected by their being sticky are less numerous, and we have no well-marked instance among our native plants. The common plumbago of South Europe is a case which many of you no doubt have observed. Other genera with the same mode of dispersion are *Pittosporum*, *Pisonia*, *Boerhavia Siegesbeckia*, *Grindelia*, *Drymaria*, etc. There are comparatively few cases in which the same plant uses more than one of these modes of promoting the dispersion of its seeds, still there are some such instances. Thus in the common burdock the seeds have a pappus, while the whole flower-head is provided with hooks which readily attach themselves to any passing animal. *Asterothrix*, as Hildebrand has pointed out, has three provisions for dispersion; it has a hollow appendage, a pappus, and a rough surface.

But perhaps it will be said that I have picked out special cases; that others could have been selected, which would not bear out, or perhaps would even negative, the inferences which have been indicated; that I have put the cart before the horse; that the ash-fruit has not a wing in order that it may be carried by the wind, or the burdock hooks that the heads may be transported by animals, but that, happening to have wings and hooks, these seeds are thus transported. Now, doubtless there are many points connected with seeds

which are still unexplained; in fact, it is because this is so that I was anxious to direct attention to the subject. Still I believe the general explanations which have been given by botanists will stand any test.

Let us take, for instance, seeds formed on the same type as that of the ash—heavy fruits, with a long wing, known to botanists as a *sa-*

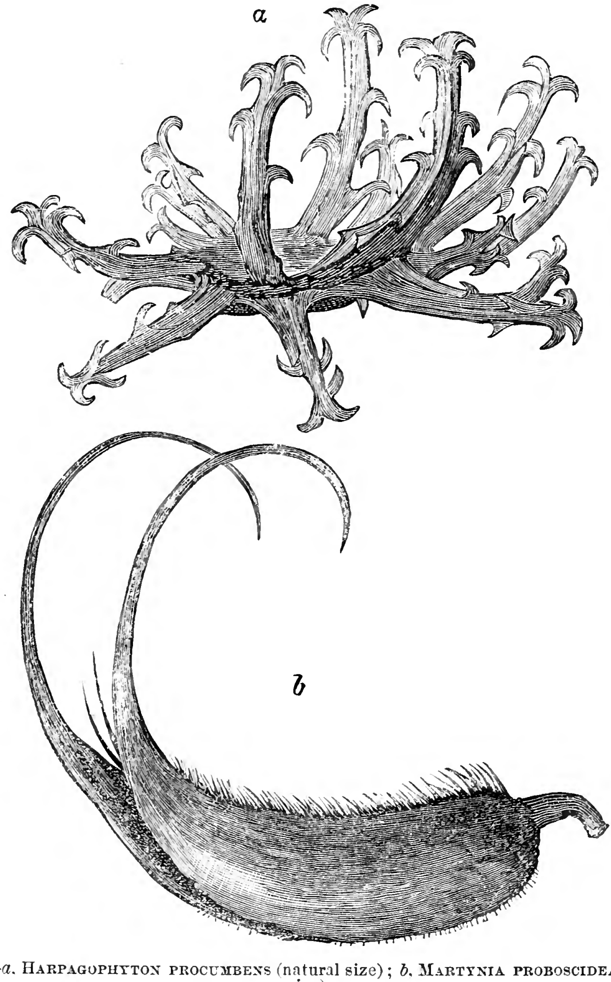


FIG. 15.—*a*. HARPAGOPHYTON PROCUMBENS (natural size); *b*. MARTYNIA PROBOSCIDEA (natural size).

mara. Now, such a fruit would be of little use to low herbs, which, however, are so numerous. If the wing was accidental, if it was not developed to serve as a means of dispersion, it would be as likely to occur on low plants and shrubs as on trees. Let us, then, consider on what kind of plants these fruits are found. They occur on the ash, maple, sycamore, hornbeam, pines, firs, and elm; while the lime, as

we have seen, has also a leaf attached to the fruits, which answers the same purposes. Seeds of this character therefore occur on a large proportion of our forest-trees, and on them alone. But more than this: I have taken one or two of the most accessible works in which seeds are figured, for instance, Gärtner's "De Fructibus et Seminibus," Le Maout and Decaisne's (Hooker's translation) "Descriptive and Analytical Botany," and Baillon's "Histoire des Plantes." I find thirty genera, belonging to twenty-one different natural orders, figured as having seeds or fruits of this form. They are all trees or climbing shrubs, not one being a low herb.

Let us take another case, that of the plants in which the dispersion of the seeds is effected by means of hooks. Now, if the presence of these hooks was, so to say, accidental, and the dispersion merely a result, we should naturally expect to find some species with hooks in all classes of plants. They would occur, for instance, among trees and on water-plants. On the other hand, if they are developed that they might adhere to the skin of quadrupeds, then, having reference to the habits and size of our British mammals, it would be no advantage for a tree or for a water-plant to bear hooked seeds. Now, what are the facts? There are about thirty English species in which the dispersion of the seeds is effected by means of hooks, but not one of these is aquatic, nor is one of them more than four feet high. Nay, I might carry the thing further. We have a number of minute plants, which lie below the level at which seeds would be likely to be entangled in fur. Now, none of these, again, have hooked seeds or fruits. It would also seem, as Hildebrand has suggested, that in point of time, also, the appearance of the families of plants in which the fruits or seeds are provided with hooks coincided with that of the land mammalia.

Again, let us look at it from another point of view. Let us take our common forest-trees, shrubs, and tall, climbing plants—not, of course, a natural or botanical group, for they belong to a number of different orders, but a group characterized by attaining to a height of say over eight feet. We will in some cases only count genera; that is to say, we will count all the willows, for instance, as one. These trees and shrubs are plants with which you are all familiar, and are about thirty-three in number. Now, of these thirty-three no less than eighteen have edible fruits or seeds, such as the plum, apple, arbutus, holly, hazel, beech, and rose. Three have seeds which are provided with feathery hairs; and all the rest, namely, the lime, maple, ash, sycamore, elm, hop, birch, hornbeam, pine, and fir, are provided with a wing. Moreover, as will be seen by the following table, the lower trees and shrubs, such as the cornel, Guelder rose, rose, thorn, privet, elder, yew, and holly, have generally edible berries, much eaten by birds. The winged seeds or fruits characterize the great forest-trees.

TREES, SHRUBS, AND CLIMBING SHRUBS NATIVE OR NATURALIZED IN BRITAIN.

	Seed or Fruit.			
	Edible.	Hairy.	Winged.	Hooked.
Clematis vitalba		×		
Berberis vulgaris				
Lime (*Tilia Europæa*)			×	
Maple (*Acer*)			×	
Spindle-tree (*Euonymus*)	×			
Buckthorn (*Rhamnus*)				
Sloe (*Prunus*)	×			
Rose (*Rosa*)	×			
Apple (*Pyrus*)	×			
Hawthorn (*Cratægus*)	×			
Medlar (*Mespilus*)	×			
Ivy (*Hedera*)	×			
Cornel (*Cornus*)	×			
Elder (*Sambucus*)	×			
Guelder rose (*Viburnum*)	×			
Honeysuckle (*Lonicera*)				
Arbutus (*Arbutus*)	×			
Holly (*Ilex*)	×			
Ash (*Fraxinus*)			×	
Privet (*Ligustrum*)	×			
Elm (*Ulmus*)			×	
Hop (*Humulus*)			×	
Alder (*Alnus*)				
Birch (*Betula*)			×	
Hornbeam (*Carpinus*)			×	
Nut (*Corylus*)	×			
Beech (*Fagus*)	×			
Oak (*Quercus*)	×			
Willow (*Salix*)		×		
Poplar (*Populus*)		×		
Pine (*Pinus*)			×	
Fir (*Abies*)			×	
Yew (*Taxus*)	×			

Or let us take one natural order. That of the roses is particularly interesting. In the genus *Geum* the fruit is provided with hooks ; in *Dryas* it terminates in a long feathered awn, like that of Clematis. On the other hand, several genera have edible fruits ; but it is curious that the part of a plant which becomes fleshy, and thus tempting to animals, differs considerably in the different genera. In the blackberry, for instance, and in the raspberry, the carpels constitute the edible portion. When we eat a raspberry we strip them off and leave the receptacle behind ; while in the strawberry the receptacle constitutes the edible portion ; the carpels are small, hard, and closely surround the seeds. In these genera the sepals are situated below the fruit. In the rose, on the contrary, it is the peduncle that is swollen and inverted, so as to form a hollow cup, in the interior of which the carpels are situated. Here you will remember that the sepals are situated above, not below, the fruit. Again, in the pear and apple, it is

the ovary which constitutes the edible part of the fruit, and in which the pips are imbedded. At first sight, the fruit of the mulberry—which, however, belongs to a different family—closely resembles that of the blackberry. In the mulberry, however, it is the sepals which becomes fleshy and sweet.

The next point is that seeds should be in a spot suitable for their growth. In most cases the seed lies on the ground, into which it then pushes its little rootlet. In plants, however, which live on trees, the case is not so simple, and we meet some curious contrivances. Thus, the mistletoe, as we all know, is parasitic on trees. The fruits are eaten by birds, and the droppings often, therefore, fall on the boughs; but if the seed were like that of most other plants it would soon fall to the ground and consequently perish. Almost alone among English plants it is extremely sticky and thus adheres to the bark.

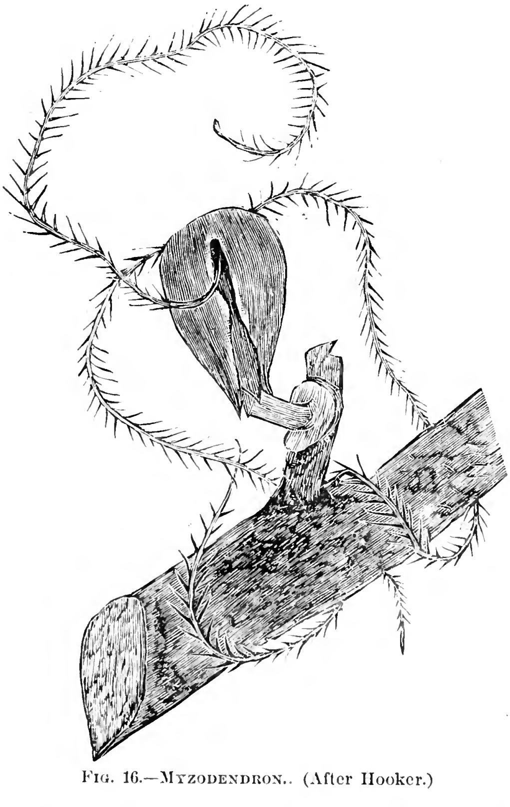


Fig. 16.—Myzodendron.. (After Hooker.)

I have already alluded to an allied genus, *Arceuthobium*, parasitic on junipers, which throws its seeds to a distance of several feet. These also are very viscid, or, to speak more correctly, are imbedded in a very viscid mucilage, so that if they come in contact with the bark of a neighboring tree they stick to it.

Another interesting genus, again of the same family, is *Myzodendron* (Fig. 16), a Fuegian species, described by Sir Joseph Hooker, and parasitic on the beech. Here the seed is not sticky, but is provided with four flattened, flexible appendages. These catch the wind, and thus carry the seed from one tree to another. As soon, however, as they touch any little bough, the arms twist round it and there anchor the seed.

In many epiphytes the seeds are extremely numerous and minute. Their great numbers increase the chance that the wind may waft some of them to the trees on which they grow; and as they are then fully supplied with nourishment they do not require to carry any store with them. Moreover, their minute size is an advantage, as they are carried into any little chink or cranny in the bark, while a larger or heavier seed, even if borne against a suitable tree, would be more

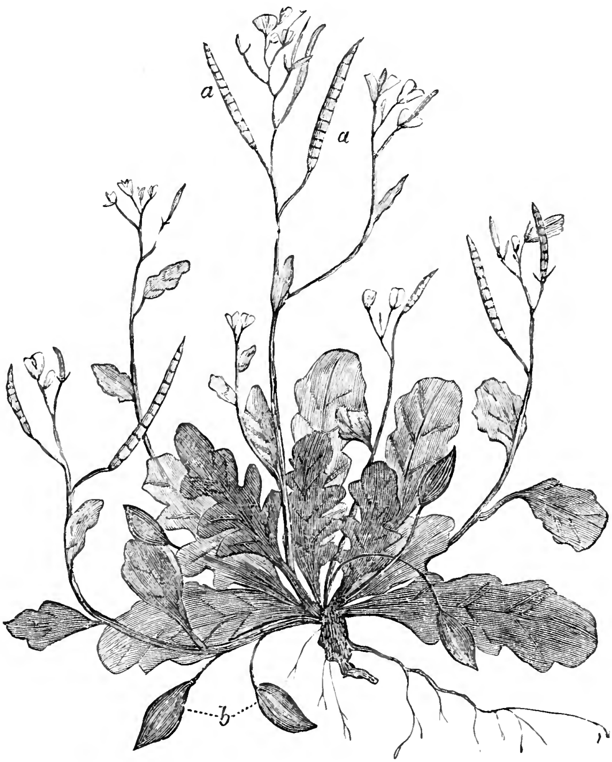


FIG. 17.—CARDAMINE CHENOPODIFOLIA. *a a*, ordinary pods; *b*, subterranean pods.

likely to drop off. In the genus *Neumannia*, the small seed is produced at each end into a long filament which must materially increase its chances of adhering to a suitable tree.

Even among terrestrial species there are not a few cases in which

plants are not contented simply to leave their seeds on the surface of the soil, but actually sow them in the ground.

Thus in *Trifolium subterraneum*, one of our rarer English clovers, only a few of the florets become perfect flowers, the others form a rigid, pointed head, which at first is turned upward, and, as their ends are close together, constitute a sort of spike. At first, I say, the flower-heads point upward like those of other clovers, but, as soon as the florets are fertilized, the flower-stalks bend over and grow downward, forcing the flower-head into the ground, an operation much facilitated by the peculiar construction and arrangement of the imperfect florets. The florets are, as Darwin has shown, no mere passive instruments. So soon as the flower-head is in the ground they begin, commencing from the outside, to bend themselves toward the peduncle, the result of which, of course, is to drag the flower-head farther and farther into the ground. In most clovers each floret produces a little pod. This

FIG. 18.—VICIA AMPHICARPA. *a a*, ordinary pods; *b b*, subterranean pods.

would in the present species be useless, or even injurious; many young plants growing in one place would jostle and starve one another. Hence we see another obvious advantage in the fact that only a few florets perfect their seeds.

I have already alluded to our cardamines, the pods of which open elastically and throw their seed some distance. A Brazilian species, *C. chenopodifolia* (Fig. 17), besides the usual long pods (Fig. 17, *a a*), produces also short, pointed ones (Fig. 17, *b b*), which it buries in the ground.

Arachis hypogæa is the ground-nut of the West Indies. The flower is yellow and resembles that of a pea, but has an elongated calyx, at the base of which, close to the stem, is the ovary. After the flower has faded, the young pod, which is oval, pointed, and very minute, is carried forward by the growth of the stalk, which becomes two or three inches long and curves downward, so as generally to force the pod into the ground. If it fails in this, the pod does not develop, but soon perishes; on the other hand, as soon as it is underground, the pod begins to grow and develops two large seeds.

In *Vicia amphicarpa* (Fig. 18), a south European species of vetch,

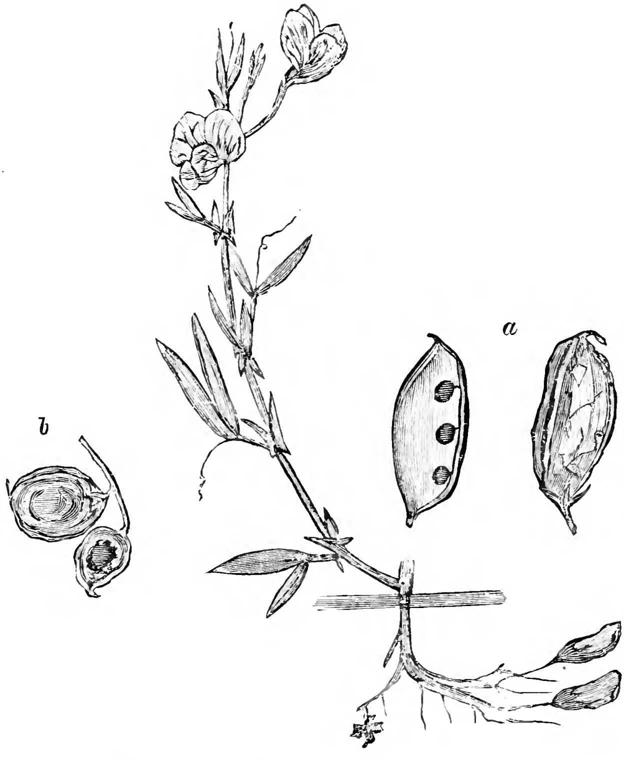


FIG. 19.—LATHYRUS AMPHICARPOS. (After Sowerby.) *a*, ordinary pods; *b*, subterranean pods.

there are two kinds of pods. One of the ordinary form and habit (*a*), the other (*b*) oval, pale, containing only two seeds, borne on underground stems, and produced by flowers which have no corolla.

Again, a species of the allied genus *Lathyrus* (Fig. 19), *L. amphicarpos*, affords us another case of the same phenomenon.

Other species possessing the same faculty of burying their seeds are *Okenia hypogæa*, several species of *Commelyna*, and of *Amphicarpæa*, *Voandzeia subterranea*, *Scrophularia arguta*, etc.; and it is very remarkable that these species are by no means nearly related, but belong to distinct families, namely, the *Cruciferæ*, *Leguminosæ*, *Commelynaceæ*, *Violaceæ*, and *Scrophulariaceæ*.

Moreover, it is interesting that in *L. amphicarpos*, as in *Vicia amphicarpa* and *Cardamine chenopodifolium*, the subterranean pods differ from the usual and aërial form in being shorter and containing fewer seeds. The reason of this is, I think, obvious. In the ordinary pods the number of seeds of course increases the chance that some will find a suitable place. On the other hand, the subterranean ones are carefully sown, as it were, by the plant itself. Several seeds together would only jostle one another, and it is therefore better that one or two only should be produced.

In the *Erodiums*, or cranesbills, the fruit is a capsule which open elastically, in some species throwing the seeds to some little distance. The seeds themselves are more or less spindle-shaped, hairy, and produced into a twisted hairy awn as shown in Fig. 20, representing a seed of *E. glaucophyllum*. The number of spiral turns in the awn depends upon the amount of moisture; and the seed may thus be made into a very delicate hygrometer, for, if it be fixed in an upright position, the awn twists or untwists according to the degree of moisture, and its extremity thus may be so arranged as to move up and down like a needle on a register. It is also affected by heat. Now, if the awn were fixed instead of the seed, it is obvious that, during the process of untwisting, the seed itself would be pressed downward, and, as M. Roux has shown, this mechanism thus serves actually to bury the seed. His observations were made on an allied species, *Erodium ciconium*, which he chose on account of its size. He found that, if a seed of this plant is laid on the ground, it remains quiet as long as it is dry; but as soon as it is moistened—i. e., as soon as the earth becomes in a condition to permit growth—the outer side of the awn contracts, and the hairs surrounding the seed commence to move outward, the result of which is gradually to raise the seed into an upright position with its point on the soil. The awn then commences to unroll, and consequently to elongate itself upward, and it is obvious that, as it is covered with reversed hairs, it will probably press against some blade of grass or other obstacle, which will prevent its moving up, and will therefore

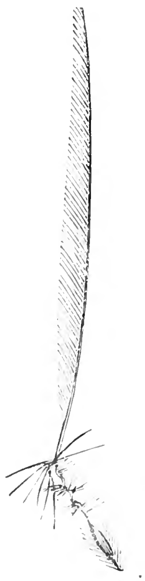


Fig. 20.—Erodium glaucophyllum. (After Sweet.)

tend to drive the seed into the ground. If, then, the air becomes drier, the awn will again roll up, in which action M. Roux thought it would tend to draw up the seed, but from the position of the hairs the feathery awn can easily slip downward, and would therefore not affect

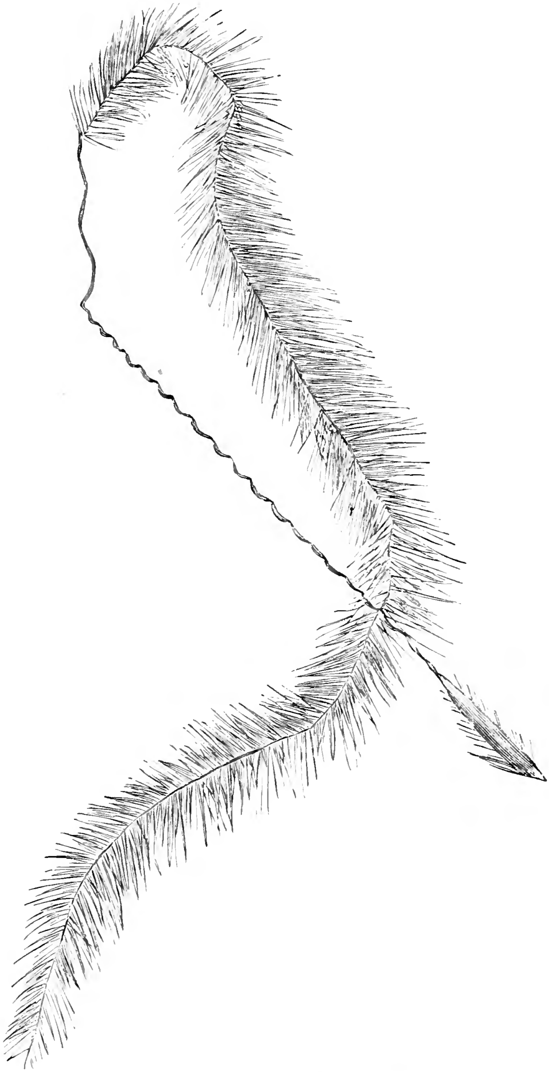


FIG. 21.—SEED OF STIPA PENNATA. (Natural size.)

the seed. When moistened once more, it would again force the seed farther downward, and so on until the proper depth was obtained. A species of anemone (*A. montana*), again, has essentially the same arrangement, though belonging to a widely separated order.

A still more remarkable instance is afforded by a beautiful South European grass, *Stipa pennata* (Fig. 21), the structure of which has been described by Vaucher, and more recently, as well as more completely, by Frank Darwin. The actual seed is small, with a sharp point, and stiff, short hairs pointing backward. The posterior end of the seed is produced into a fine twisted corkscrew-like rod, which is followed by a plain cylindrical portion, attached at an angle to the corkscrew, and ending in a long and beautiful feather, the whole being more than a foot in length. The long feather, no doubt, facilitates the dispersion of the seeds by wind; eventually, however, they sink to the ground, which they tend to reach; the seeds being the heaviest portion, point downward. So the seed remains as long as it is dry, but if a shower comes on, or when the dew falls, the spiral unwinds, and if, as is most probable, the surrounding herbage or any other obstacle prevents the feathers from rising, the seed itself is forced down and so driven by degrees into the ground.

I have already mentioned several cases in which plants produce two kinds of seeds, or at least of pods, the one being adapted to burying itself in the ground. Heterocarpism, if I may term it so, or the power of producing two kinds of reproductive bodies, is not confined to these species. There is, for instance, a North African species of corydalis (*C. heterocarpa* of Durieu) which produces two kinds of seed (Fig. 22), one somewhat flattened, short, and broad, with rounded angles; the other elongated, hooked, and shaped like a shepherd's crook with a thickened staff. In this case the hook in the latter form perhaps serves for dispersion.

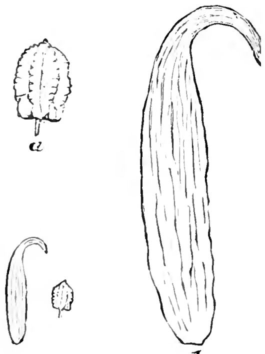


Fig. 22.—Seeds of Corydalis heterocarpa.

Our common *Thrincia hirta* (Fig. 13, *b*) also possesses, besides the fruits with the well-known feathery crown, others which are destitute of such a provision, and which probably, therefore, are intended to take root at home.

Mr. Drummond, in the volume of "Hooker's Journal of Botany" for 1842, has described a species of *Alismaceæ* which has two sorts of seed-vessels; the one produced from large, floating flowers, the other at the end of short, submerged stalks. He does not, however, describe either the seeds or seed-vessels in detail.

Before concluding, I will say a few words as to the very curious forms presented by certain seeds and fruits. The pods of Lotus, for instance, quaintly resemble a bird's foot, even to the toes; whence the specific name of one species, *Ornithopodioides*; those of *Hippocrepis* remind one of a horseshoe; those of *Trapa bicornis* have an absurd resemblance to the skeleton of a bull's head. These likenesses appear to be accidental, but there are some which probably are of use to the

plant. For instance, there are two species of Scorpiurus (Fig. 23), the pods of which lie on the ground, and so curiously resemble the one (*S. subvillosa*, Fig. 23, *a*) a centiped, the other (*S. vermiculata*, Fig. 23, *b*) a worm or caterpillar, that it is almost impossible not to suppose that the likeness must be of some use to the plant.

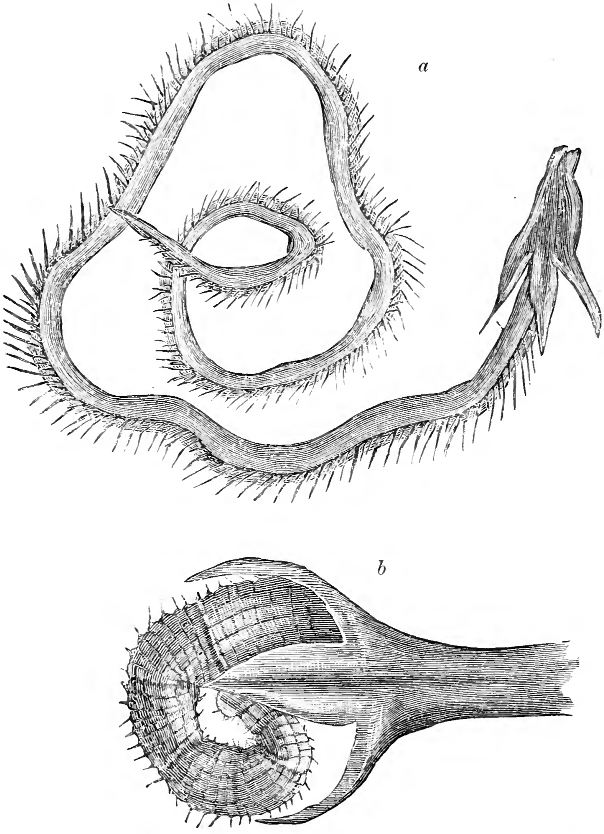


FIG. 23.—*a*, POD OF SCORPIURUS SUBVILLOSA ; *b*, POD OF SCORPIURUS VERMICULATA.

The pod of *Biserrula pelecinus* (Fig. 24, *a*) also has a striking resemblance to a flattened centiped ; while the seeds of *Abrus precatorius*, both in size and in their very striking color, mimic a small beetle, *Artemis circumusta*.

Mr. Moore has recently called attention to other cases of this kind. Thus the seed of *Martynia diandra* much resembles a beetle with long antennæ : several species of Lupins have seeds much like spiders, and those of *Dimorphochlamys*, a gourd-like plant, mimic a piece of dry twig. In the common castor-oil plants (Fig. 24, *b*), though the resemblance is not so close, still at first glance the seeds might readily

be taken for beetles or ticks. In many Euphorbiaceous plants, as, for instance, in Jatropha (Fig. 24, *c*), the resemblance is even more striking. The seeds have a central line resembling the space between the elytra, dividing and slightly diverging at the end, while between them the end of the abdomen seems to peep; at the anterior end the seeds possess a small lobe, or caruncle, which mimics the head or thorax of

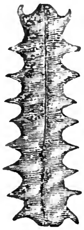


Fig. 24 *a*.—Pod of Biserrula.

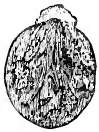


Fig. 24 *b*.—Seed of Castor-Oil (Ricinus).

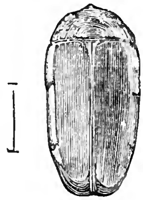


Fig. 24 *c*.—Seed of Jatropha.

the insect, and which even seems specially arranged for this purpose; at least it would seem from experiments made at Kew that the caruncculus exercises no appreciable effect during germination.

These resemblances might benefit the plant in one of two ways. If it be an advantage to the plant that the seeds should be swallowed by birds, their resemblance to insects might lead to this result. On the other hand, if it be desirable to escape from graminivorous birds, then the resemblance to insects would serve as a protection. We do not, however, yet know enough about the habits of these plants to solve this question.

Indeed, as we have gone on, many other questions will, I doubt not, have occurred to you, which we are not yet in a position to answer. Seeds, for instance, differ almost infinitely in the sculpturing of their surface. But I shall wofully have failed in my object to-night if you go away with the impression that we know all about seeds. On the contrary, there is not a fruit or a seed, even of one of our commonest plants, which would not amply justify and richly reward the most careful study.

In this, as in other branches of science, we have but made a beginning. We have learned just enough to perceive how little we know. Our great masters in natural history have immortalized themselves by their discoveries, but they have not exhausted the field; and, if seeds and fruits can not vie with flowers in the brilliance and color with which they decorate our gardens and our fields, still they surely rival—it would be impossible to excel them—in the almost infinite variety of the problems they present to us, the ingenuity, the interest, and the charm of the beautiful contrivances which they offer for our study and our admiration.—*Fortnightly Review.*

HOW TO PREVENT DROWNING.

By HENRY MacCORMAC.

I WISH to show how drowning might, under ordinary circumstances, be avoided, even in the case of persons otherwise wholly ignorant of what is called the art of swimming. The numerous frightful casualties render every working suggestion of importance, and that which I here offer I venture to think is entirely available.

When one of the inferior animals takes the water, falls or is thrown in, it instantly begins to walk as it does when out of the water. But, when a man who can not "swim" falls into the water, he makes a few spasmodic struggles, throws up his arms, and drowns. The brute, on the other hand, treads water, remains on the surface, and is virtually insubmergible. In order, then, to escape drowning, it is only necessary to do as the brute does, and that is to tread or walk the water. The brute has no advantage in regard of his relative weight, in respect of the water, over man, and yet the man perishes while the brute lives. Nevertheless, any man, any woman, any child who can walk on the land may also walk in the water, just as readily as the animal does, if only he will, and that without any prior instruction or drilling whatever. Throw a dog into the water, and he treads or walks the water instantly, and there is no imaginable reason why a human being under like circumstances should not do as the dog does.

The brute, indeed, walks in the water instinctively, whereas the man has to be told. The ignorance of so simple a possibility, namely, the possibility of treading water, strikes me as one of the most singular things in the history of man, and speaks very little indeed for his intelligence. He is, in fact, as ignorant on the subject as is the newborn babe. Perhaps something is to be ascribed to the vague meaning which is attached to the word *swim*. When a man swims it means one thing, when a dog swims it means another and quite a different act. The dog is wholly incapable of swimming as a man swims, but nothing is more certain than that a man is capable of swimming, and on the instant, too, as a dog swims, without any previous training or instruction, and that, by so doing without fear or hesitancy, he will be just as safe in the water as the dog is.

The brute in the water continues to go on all-fours, and the man who wishes to save his life, and can not otherwise swim, must do so too, striking alternately, one two, one two, but without hurry or precipitation, with hand and foot, exactly as the brute does. Whether he be provided with paw or hoof, the brute swims with the greatest ease and buoyancy. The human being, if he will, can do so too, with the further immense advantage of having a paddle-formed hand, and

of being able to rest himself when tired by floating, a thing of which the animal has no conception. Bridget Money, a poor Irish immigrant, saved her own life and her three children's lives, when the steamer conveying them took fire on Lake Erie, by floating herself, and making them float, which simply consists in lying quite still, with the mouth shut and the head thrown well back in the water. The dog, the horse, the cow, the swine, the deer, and even the cat, all take to the water on occasion, and sustain themselves perfectly without any prior experience whatever. Nothing is less difficult, whether for man or brute, than to tread water, even for the first time. I have done so often, using the feet alone, or the hands alone, or the whole four, many times, with perhaps one of my children on my back. Once I recollect being carried a good way out to sea by the receding tide at Boulogne, but regained the shore without difficulty. A drop of water once passed through the rima of the glottis, and on another occasion I experienced such sudden indisposition that, if I had been unable to float, it must, I think, have gone hard with me.

Men and animals are able to sustain themselves for long distances in the water, and would do so much oftener were they not incapacitated, in regard of the former at least, by sheer terror, as well as complete ignorance of their real powers. Webb's wonderful endurance will never be forgotten. But there are other instances only less remarkable. Some years since, the second mate of a ship fell overboard while in the act of fisting a sail. It was blowing fresh; the time was night, and the place some miles out in the stormy German Ocean. The hardy fellow nevertheless managed to gain the English coast. Brock, with a dozen other pilots, was plying for fares by Yarmouth; and, as the main-sheet was belayed, a sudden puff of wind upset the boat, when presently all perished except Brock himself, who, from four in the afternoon of an October evening to one the next morning, swam thirteen miles before he was able to hail a vessel at anchor in the offing. Animals themselves are capable of swimming immense distances, although unable to rest by the way. A dog recently swam thirty miles in America in order to rejoin his master. A mule and a dog washed overboard during a gale in the Bay of Biscay have been known to make their way to shore. A dog swam ashore with a letter in his mouth at the Cape of Good Hope. The crew of the ship to which the dog belonged all perished, which they need not have done had they only ventured to tread water as the dog did. As a certain ship was laboring heavily in the trough of the sea, it was found needful, in order to lighten the vessel, to throw some troop-horses overboard, which had been taken in at Corunna. The poor things, my informant, a staff-surgeon, told me, when they found themselves abandoned, faced round and swam for miles after the vessel. A man on the east coast of Lincolnshire saved quite a number of lives by swimming out on horseback to vessels in distress. He commonly rode an old gray

mare, but, when the mare was not to hand, he took the first horse that offered.

The loss of life from shipwreck, boating, bathing, skating, fishing, and accidental immersion is so disastrously great, that every feasible procedure calculated to avert it ought to be had recourse to. People will not consent to wear life-preservers, but, if they only knew that in their own limbs, properly used, they possessed the most efficient of life-preservers, they would most likely avail themselves of them. In every school, every house, there ought to be a slate tank of sufficient depth, with a trickle of water at one end and a siphon at the other, in order to keep the contents pure. A pail or two of hot water would at any time render the contents sufficiently warm. In such a tank every child from the time it could walk ought to be made to tread water daily. Every adult, when the opportunity presents itself, should do so. The printed injunction should be pasted up on all boat-houses, on every boat, at every bathing-place, and in every school. "Tread water when you find yourself out of your depth" is all that need be said, unless, indeed, we add, "Float when you are tired." Every one, of whatever age or sex, or however encumbered with clothing, might tread water with at least as much facility, even in a breaking sea, as a four-footed animal does. The position of a person who treads water is, in other respects, very much safer and better than is the sprawling attitude which we assume in ordinary swimming. And then the beauty of it is that we can tread water without any preliminary teaching, whereas "to swim" involves time and pains, entails considerable fatigue, and is very seldom adequately acquired, after all.

The Indians on the Missouri River, when they have occasion to traverse that impetuous stream, invariably tread water just as the dog treads it. The natives of Joanna, an island on the coast of Madagascar, young persons of both sexes, walk the water, carrying fruit and vegetables to ships becalmed, or it may be lying-to, in the offing miles away. Some Kroomen, whose canoe upset before my eyes in the seaway on the coast of Africa, walked the water, to the safe-keeping of their lives, with the utmost facility; and I witnessed negro children on other occasions doing so at a very tender age. At Madras, watching their opportunity, messengers, with letters secured in an oil-skin cap, plunge into the boiling surf, and make their way, treading the water, to the vessels outside, through a sea in which an ordinary European boat will not live. At the Cape of Good Hope men used to proceed to the vessels in the offing through the mountain-billows, treading the water as they went with the utmost security. And yet here, on our own shores, and amid smooth waters, men, women, and children perish like flies annually, when a little properly-directed effort—treading the water as I have said—would haply suffice to rescue them every one.—*Nature.*

RECENT ADVANCE IN THE LAW OF INTELLECTUAL PROPERTY.

By BENJAMIN VAUGHAN ABBOTT.

THE indications seen during the past two years of advance in the law protecting intellectual property are interesting and important. This article will describe some of the more salient steps—the legislation and lately reported decisions—which are of interest to all friends of practical science. That such readers have a general knowledge of the system which has been established by Congress in order "to promote the progress of science and the useful arts"—the patent and copyright laws—may be taken for granted. Without rehearsing principles that have been long established, let us speak at once of matters lately questioned or newly declared.

During the last decade trade-marks became associated in the public mind with patents, owing to the fact that in 1870, when a codified statement of the patent and copyright laws was moved in Congress, that body interleaved a chapter embodying a national trade-mark law. This was done apparently on the theory that the three subjects were so homogeneous as to warrant considering trade-marks embraced within the constitutional power; and this position stood unchallenged for several years. But, when challenged, it was overthrown. The Supreme Court pointed out that the power is limited to securing to authors and inventors the right to their *writings* and *discoveries;* and said that a trade-mark can not be classified either with inventions or discoveries in the arts and sciences, or with the writings of authors; and that, if any law of Congress on the subject can be sustained, it must be one limited to marks intended for foreign (or Indian) commerce. An act has been passed (March 3, 1881) conforming to this view. It authorizes inhabitants of the United States or of any foreign country which reciprocates to register trade-marks, and protects their use in foreign (and Indian) commerce only. Trade-marks have thus been distinctly dissociated from inventions, as they should be.

Just as naturalists pronounce it difficult to draw a distinct line between plants and animals, so lawyers are finding confusion between what is a book, what a machine. A new system of book-keeping, consisting of a book of forms or blanks, the pages of which contained ruled lines and headings showing how a merchant's account-book might be prepared on a new and advantageous plan, was copyrighted; but the Court, when an imitator was sued, said that all that could be secured under the copyright law was the right to print the introductory essay, and the particular columns and headings by way of sample. To secure the control of the new system of book-keeping, the contriver

of it should have taken out a patent; for want of this, any one not reprinting his book had the right to make and use account-books framed on his plan. By way of contrast is the story of a large blank-book, each page of which was marked in spaces, these spaces being numbered to correspond with imaginary bonds and coupons, the idea being that as fast as coupons should be paid they might be kept each in the space appropriate to its number, or any notice received relative to a bond outstanding might be pasted in the space allotted to that bond, for ready reference. The contriver of this "book" patented it, and the Court said that he was right; it was not a literary work, but an invention.

All know that during ten years past improvements in the Office have been made, of which the system of printing patents for distribution and the issue of the "Gazette" are prominent examples. Improvements continue. The classification of subjects of invention has been revised, and is republished in the "Gazette" for January 4th last. As now framed it arranges patented inventions in twenty-four divisions, these being divided into one hundred and sixty-four classes, and these again into nearly three thousand sub-classes. Persons desiring to inform themselves with regard to the state of the art in any line of invention can gain much knowledge by procuring the specifications and drawings in the sub-class containing such invention, or can subscribe for future specifications and drawings in any desired class.

The number of patents which have been issued has now reached nearly a quarter of a million. To examine as many of them as is often necessary for determining the novelty of an application involves so much delay and expense that three successive commissioners have earnestly recommended the preparation of a digest. Congress, this spring, authorized this work, and appropriated ten thousand dollars for the expense.

There have been noteworthy decisions on the effect of an inventor's disclosure of his invention, or of his delay in applying for a patent, to impair his right. They indicate that the importance to inventors of "keeping their own counsel" is not sufficiently understood. An inventor may make use of his invention to test its operation, ascertain its defects, and mature improvements, quite freely; and, if these are his purposes, the facts that the use was openly known and was beneficial to the public are not fatal to his right. For example, the patent for the Nicholson pavement was contested on a showing that in 1854, before applying for a patent, the inventor laid a block of the pavement in a Boston street to test its merits. The Supreme Court said that as he had not used or allowed others to use it for profit, but only by way of experiment, there was no abandonment. But a slight disclosure by way of sale or manufacture for sale may destroy the right. For example, an inventor's making three sets of articles of ladies' wear for two ladies of his acquaintance, who wore them until they were worn

out, was pronounced an abandonment of his invention, because it was not a use for experiment or in private, but a practical use of the completed article. Even a single sale to a buyer, who bought the thing only "on trial," has been pronounced an abandonment.

A case of some hardship was that of a card-manufacturer who ran machines of his invention for several years under arrangements intended to secure secrecy: a limited number of workmen were employed; the factory-doors were kept locked, each workman having a key; and visitors were but rarely admitted. Yet no formal pledge of secrecy was exacted from those who saw the machine. In course of time the inventor obtained a patent, but in the mean time his foreman had "given away" the secret to competitors. The Judge said that an inventor's conducting his business so that the public have an opportunity of knowing and imitating his invention forfeits his right, without proof that any great number of persons knew it. If any one knew it under such circumstances that he might have made it public without a breach of confidence, the right is abandoned.

With respect to delay, while it is familiar that an inventor is not limited to any particular time within which he must apply, yet the Supreme Court has lately said, quite emphatically, that, unless he is vigilant and active in applying, or there is good excuse, such as sickness, poverty, etc., for his postponement, he runs the risk that his invention will be considered abandoned to the public. The story of the case was, that Woodbury, in 1848, applied for a patent for an improvement in planing-machines, but it was rejected. He took no further steps until 1870, and meantime the principle of his invention had been adopted by other persons. Then he obtained a patent; but it was annulled for his long neglect. Inventors should be wary of disclosure and delay.

A decision of the Supreme Court known as Mitchell *vs.* Tilghman (19 Wall., 287) has given some persons an idea that a process can not be the subject of a patent; though the intention was, only to decide that the patentee was confined in his right to the particular method pointed out in his specification. He litigated the case further, gathered additional evidence, and presented the question to the Court again; and the Court has in effect overruled its former decision, now explaining emphatically that a patent may be, under American law, granted for a process. Our patent law is not confined to new machines and new compositions of matter, but extends to any new and useful art of manufacture; and a manufacturing process is clearly an art. The principle is that, whoever discovers that a certain useful result will be produced in any art by the use of certain means, is entitled to a patent, provided he fully and accurately specifies the means. This means need not be a machine or an apparatus; it may be a process. A machine is a thing. A process is a mode of action. The one is visible to the eye—an object of perpetual observation. The other is a

conception of the mind seen only by the effect it produces while performed. But either may be the means of producing a useful result. The mixing of certain substances together or the heating of a substance to a certain temperature is a process. If the mode of doing it or the apparatus in or by which it may be done is sufficiently obvious to suggest itself to a person skilled in the particular art, then pointing out in the patent the process to be performed is sufficient, without giving directions, which would be supererogatory, as to the apparatus or method to be employed. If the mode of applying the process is not obvious, then to give a description of the process and of one particular mode by which it may be applied is sufficient. It may be that the process is susceptible of being applied in many modes and by the use of many forms of apparatus; but the inventor, if really the discoverer of the process, is not bound to describe all these in order to secure his exclusive right to it. What is required is, that he shall describe some particular mode or apparatus so as to show that the process is capable of being exhibited and performed in actual use. This is the latest utterance of the Supreme Court on the lawfulness of a patent for a process.

A decision comes from England bearing upon the value of such patents. The inventor of an improved process for making salicylic acid obtained a patent in England; but was soon undersold by an inventor of a rival process, who established a factory in Germany and brought the acid manufactured there into England for sale. The patentee brought suit. The counsel for the German manufacturer argued that the patent forbade only manufacturing in England. It did not forbid manufacturing in Germany, and any goods lawfully manufactured in Germany might be brought into England for sale. "Suppose," said he, "some one patents a process for making flour by crushing wheat instead of grinding it, and French millers, generally, adopt the mode. Is it thereafter unlawful to import flour from France?" But the Court of Appeal decided in favor of the patentee, saying that the exclusive right secured by a patent for a process must be considered to include a monopoly of the sale in England of products made according to the process, no matter where they are manufactured. For these patents expressly forbid any person directly or indirectly to use the process. Now, a person who procures the product to be made in a foreign country and then brings it to England for sale is certainly using the invention "indirectly."

Many illustrations are noticed in recent books of reports, of the expense and loss sustained by inventors through obtaining patents for trivial devices. They know, theoretically, that a patent, to be sustained in the courts, must be for an invention which is "new and useful"; but fail, practically, to apply the test. Evidently the existing system tends to betray an over-sanguine inventor. A solicitor of patents will cheerfully take a fee and undertake to obtain letters.

The patent-office will accept further fees; will make an examination for novelty, which is good, as far as it goes, and in some measure a protection against launching an unprofitable venture; and will grant a patent. A lawyer will readily spend a few hundred dollars in organizing a company, and will execute his task skillfully: he has no responsibility for the mercantile value of the project. Two or three thousand dollars more are easily expended in facilities for manufacture, in starting a sales-room, and in advertising. And yet, after all this expenditure, involving also the inventor's time, the moment the patent is contested by an infringer, the courts may pronounce it void for want of novelty. Notice recent examples. The "Perfection Window-Cleaner" was in substance a rubber mounted on a long handle convenient for reaching up to clean lofty windows and the like; the peculiarity of the device consisting in the way in which a cushion for rubbing was adjusted so that it could be pressed against the surface to be cleaned. The Court said that there was nothing new in this; the implement was only a mop or scrubbing-brush made of India-rubber. "Improved Kindling-Wood" was patented, consisting of wood tied in small bundles, each containing a lump of combustible matter which would take fire from a common match. The Court said that there was no more invention in this than there would be in selling a sherry-cobbler glass with a straw in it, or a can of food with a fork. As at first devised, the "Fare-Box" used in city omnibuses and street-cars was inefficient for want of an opportunity to the driver to see whether the proper fare had been put in. Some one obtained a patent for the improvements of fitting a second window, and a reflector, in such manner that the driver might, either by day or night, see the coin which had been deposited. With these changes the fare-box became a success. But the Court said that there was no invention in inserting an additional window, or in putting a reflector near a lamp. To relieve drivers from the necessity of buying a new whip because the tip-end had become frayed or broken while the stock remained good, an inventor contrived "Whip-Tips" with sockets, so that a worn one might be unscrewed and a new one screwed on in its place. The Court said that he might sustain an exclusive right to his screw, but that the important feature of the device—making independent tips to be substituted for worn ones—was not new; this is the principle upon which fishing-rods in sections have been made for many years. The "Rubber-tip Pencil" has had an extensive sale; but, when the patent for it was contested, the Court said that there was no invention; the device was nothing but "a piece of rubber with a hole in it." Not many years ago a patent was questioned for an article called "Comminuted Glue." The device consisted in breaking glue into small particles, of uniform size, to facilitate dissolving it for use. The Court said that nothing was here involved other than grinding glue fine, and grinding can not be called a new invention. A score of such decisions might

easily be gathered from the court reports of the past two years, showing very clearly that inventors need to be on their guard against soliciting patents for trivialities.

That an applicant for a patent must frankly and fully disclose his invention, but that if his description is, through accident or mistake, insufficient, he may have a "reissue" correcting the mistake, is familiar, yet not so well understood but that new explanations have been found needful. The volume published last summer of Justice Clifford's decisions contains a case in which he assigns three reasons for requiring fullness and accuracy in the description: 1. That the Government may know what they have granted, and what will become public property when the term of the monopoly expires; 2. That licensed persons, desiring, during the term, to practice the invention, may know how to make, construct, and use it; 3. That other and subsequent inventors may know what part of the field of invention remains unoccupied.

The privilege of reissue has no doubt been abused. A glaring case was presented in the Supreme Court. An inventor applied for a patent, but the Commissioner thought that he claimed too much, and refused letters unless the applicant would omit a part. He did so, and a patent was issued for the invention, the description being limited according to the Commissioner's view. Several years afterward, he applied for a reissue, to include the feature of his invention formerly rejected, and, through some error, it was granted. The Supreme Court Judges say that this, though it has often been done, is a fraud on the public. Reissues can only be allowed to cure errors attributable to inadvertence, accident, or mistake. What was omitted from the first patent, because the inventor consented to abandon it, can never be lawfully brought in afterward by a reissue.

Several lawsuits have culminated in a group of decisions which, if they shall be sustained by the Supreme Court, will open the way to an efficient judicial remedy, whenever Government officers assume to use a patented invention. The English idea has long been that a patent is a monopoly or privilege which the Crown—though forbidden to grant monopolies as freely as might be done centuries ago—may give to a favored person. Hence it is there considered that the privilege does not prevail against Government. The Crown does not engage not to use the improvement. Upon the American view, a patent is a compact made with the inventor to induce him to disclose his invention for the public benefit; as a reward for which he receives an exclusive privilege which is in the nature of property. As respects many important inventions, the privilege would have little value if not good against Government, for the reason that the thing is only useful in Government business. What would be the worth of a patent for articles useful only in the army and navy, for a revenue or postage stamp, or the like, if Government might use the invention free? Offi-

cers have, however, influenced by what is said in English books, often supposed that no royalty need be paid when Government authorizes the use. Thus, a while ago, an army officer who contrived an improved cartridge-box submitted it to the War Department, and the department adopted it, but refused to pay the inventor. He sued in the Court of Claims, which said that the case was to be treated as if Government had agreed to pay a reasonable price. More recently, when Mr. James, the Postmaster of New York City, used a patented invention for canceling postage-stamps, with the result of saving to the Government, through a term of years, some sixty thousand dollars, the Circuit Court said that he must pay damages in the same light as if he had been an infringer on his own account, and must obtain reimbursement from Congress as he might be able. Attorney-General Devens gave an official opinion to the like effect. Upon the theory of these decisions, if a patented invention is used in Government business with the inventor's consent, the Court of Claims may award him compensation upon an implied contract to pay; or, if it is used against his will, he may prosecute the officer as an individual, and the interest of Government in the matter will be no defense.

RECENT ADVANCES IN ELECTRIC LIGHTING.*

By W. H. PREECE.

ADVANCES have been made, not so much in electric lighting itself as in the popular favor with which it is regarded. The public is becoming more accustomed to its use, and is acquiring more confidence in it. The result of trials during the last year or two has been to make the defects of the electric light better known. It has been taken out of the experimental stage, and brought within reach of the practical stage. The principal fact which has brought the electric light to the front has been the substitution of machinery for the direct conversion of mechanical energy into electricity for the expensive batteries which were the only sources a few years ago. Machines, working with high velocity, great steadiness, and uniform pressure, have solved the problem of cheap electricity. The amount of coal required to produce one horse-power has been reduced from seven and eight pounds to three and even two pounds. The gas-engine—a very economical source of energy—has been successfully applied to electric lighting in many places. Such an engine has been used at the docks in Newport, South Wales, to produce a light of eleven times the power that the same gas would give if used directly.

* Abstract of a lecture before the London Society of Arts.

Here is a sphere in which gas companies may maintain their dividends. Water furnishes a convenient source of energy wherever it can be found available. Sir William Armstrong makes his brook light his house, producing from it, by the aid of a turbine, a force giving six horse-power. The caloric-engine at the Lizard Lighthouse has been found to be economical, useful, and very suitable for an isolated place where it is hard to provide water.

The difference in the value of the several excellent machines employed for generating the current is not great. Each is especially adapted for its own particular work, either by a variation in velocity or by a variation in the manner in which the wire is wound, so as to produce a variation in the current produced to suit the particular light required. In both the Siemens and the Gramme machines ninety per cent. of the power is converted into useful current. It is easily demonstrable that there is economy in the use of small machines. Trials made for the Trinity House have shown that more efficiency is obtained by joining small machines in multiple arc than by using a larger machine, or joining the same small machines in series.

For conducting-wires the preference is given to copper, the purest that can be got, and wire of the largest dimensions consistent with economy, so as to keep the resistance as low as possible and avoid waste of energy. When it can be carried overhead, facility is given for the radiation of the heat into the air, and the wire is kept cool and conveys more electricity. Since the currents to be carried over these wires are three thousand times larger than those used in telegraphy, the difficulties to be encountered in their safe transmission are greatly magnified. The disturbing effects produced by the inductive influence of such currents are so serious that apprehensions are entertained that it will be impossible to maintain electric light and telegraph currents close together.

The electric light is coincident with electric heat ; the art of producing a brilliant light is the art of producing a high temperature. No greater illusion is extant than the idea that the electric light is a cold light, for the electric arc is the greatest source of heat known. This heat can be produced either by causing the electricity to fly across an air-space, in which case we have light by the arc, or an arc-light, or by causing it to flow through a small wire or a carbon filament, which offers obstruction to the flow and produces light by incandescence, or the incandescent light. The forms of arc-lamps are very numerous. In every case carbon rods are opposed to each other, and are disintegrated and consumed in the fierce blast to which they are subjected. The lower pole—the negative—acquires a temperature of 3,150° C. (5,702° Fahr.), and is broken up and fired in a fierce bombardment of white-hot molecules across the air against the upper pole —the positive—which is beaten up by incessant impacts into a higher temperature of 3,900° C. (7,052° Fahr.), the arc itself being 4,800° C.

(8,672° Fahr.). A number of ingenious appliances have been adopted to obtain steadiness and uniformity in the action of the arc, which is liable to variations arising from the irregularity in the character and consequently in the consumption of the carbon, and from variations in the strength of the current. We want brilliancy combined with absolute steadiness, and a durability equal to the length of a winter's night. All the improvements that have been made in the arc have not given a silent and steady light.

The incandescent light is free from many of the defects of the arc-light. In it we have something that is beautifully soft, absolutely noiseless—a light that brightens up Nature in all her true colors and purity. It, however, requires a considerable expenditure of power, and is at present an expensive luxury. Sir William Armstrong finds that six horse-power will supply thirty-seven lights, giving altogether the illumination of nine hundred and twenty-five candles. The same power applied to arc-lights would give more than six thousand candles. But rapid progress has been made in this field. Maxim, Edison, etc., in America—Swan, Lane-Fox, and others, in England—are working hard; while Gordon and Joel are working in an intermediate field, in which a prospect appears of a happy compromise being effected between the arc and incandescence.

Some wild statements, involving wonderfully divergent estimates, have been made about the light-giving power of the different lights. A standard sperm-candle, although it may be a good unit to measure gas by, is a very poor standard for the electric light. None of the various modes of measurement in use seem to apply exactly to this light, and the standard of measurement of the future has yet to be found. Much is said about the subdivision of the electric light by certain gentlemen, who hope to distribute it throughout our houses from one central spot, and furnish it cheaply and abundantly in our cities. I am one of those who do not believe in the impossible, but I say that, with our present knowledge, this problem is unsolvable. Sir William Armstrong can only keep thirty-seven lamps going; Lane-Fox could only show twelve lights; Professor Adams could only produce from the most powerful dynamo-electric machine, by calculation, one hundred and forty lamps. Where is the subdivision? The advocates of subdivision assume an inexhaustible source of electricity. Their opponents reply that there is but a very limited source of energy in every dynamo-electric machine. It may be that more powerful machines and lamps of lower resistance may enable us to light up a greater number on one circuit, but this is not subdivision, it is multiplication.

For application to external illumination, we have, first, the centralized system of Dr. Siemens, in which one machine works one powerful light, raised like a small moon on the top of a high mast; and, secondly, the distributed system of the Brush Company, who utilize the existing

street lamp-posts, one machine working many lights. The former system appears to be the best for symmetrical spaces and large areas, the latter for long and narrow streets and thoroughfares ; so, in internal illumination, the central system is preferable for lofty, spacious rooms, the distributed for long and low ones.

An eventful feature in practical lighting is the proper scattering or diffusion of light, by shades, screens, and reflecting surfaces. We want to emulate the diffusion of daylight. It is marvelous how whitewashed surfaces do this. Well-selected globes act as though they were self-luminous ; they scatter light and produce shadows. The power of the light, however, to penetrate fogs does not appear to be any greater than that of gaslight. This is because the shorter-waved rays that give the light its violet tint are checked by the vapors, in the same manner as the like rays in the sun are checked, and it is made to appear red. The same cause operates to give the electric light a greater illuminating power in its immediate neighborhood, for the checked rays are reflected back to add their intensity to that of the direct rays.

Nearly three hundred Gramme machines are in use in England generating light ; there are many more Siemens machines, and the Brush people have installed many machines and lights. Nearly all the ironclads in the navy are supplied with the electric light. In libraries, while reading by gaslight is irksome, reading by the electric light is simply delightful. Railway-stations are gradually adopting the lights ; seaside resorts are illuminating their parades with them. It would be impossible to make any summary of the numerous manufacturing establishments that have been supplied with lights worked successfully.

Notwithstanding these great advances in its use, it must not be forgotten that the electric light has its defects and its disadvantages. The intense shadows that it occasions are troublesome. The unsteadiness of the light is at times wearisome. The hissing which impurities in the carbon and irregularities in the current produce is tantalizing, and the light has an unfortunate habit of misbehaving itself when it is most wanted. Moreover, the problem of durability remains yet to be solved. Many have tried the light and abandoned it. In some cases its economy is unquestionable, but there are places where careful persons have shown that gas, as regards economy, surpasses it. It is questionable whether, in some cases, the electric light does not affect the eye. The arc-light produces, also, nitrous acid and other deleterious gases, but the incandescent lamp is free from this trouble. The powerful currents that it requires can not be carried over buildings and rooms without incurring danger from fire and to life. Nevertheless, the light has great and manifold advantages. The brilliancy of a well-lighted room is simply enchanting. The purity of the light for the transaction of business, the selection of colors, and the ordinary daily avocations of life, is simply superb. Its cleanliness is one of its great merits. It

emits no smoke. Probably its greatest advantage is to be found in the influence it exerts on health. At Glasgow, where the light has been applied, all causes of trouble arising from the vitiation which was occasioned by other lights have ceased. Health has been engendered, and more work has been got out of the men; and experience has shown that the electric light will pay for itself in the superior return it makes in this point alone.

Mr. Preece has published in a separate paper some facts bearing upon the economy of the electric light. The Loan Court of the South Kensington Museum, a room not favorably arranged for the diffusion of light, has been lighted for nine months with sixteen Brush lamps, at a cost for working of 3*s.* 10*d.* per hour of light. Had gas been used, a consumption of sixteen hundred cubic feet per hour would have been required, at a cost of 16*s.* Considering that the museum is lighted up for seven hundred hours every year, the total saving effected by the use of electricity is at the rate of £426 or $2,130 a year. It is fair, however, to add something for the use of the capital, wear and tear, etc., to the annual expense. Reckoning this at five per cent. all around, the annual saving is still £316 10*s.*, or $1,580. The reading-room of the British Museum is lighted by the Siemens electric light, at a cost of 5*s.* 6*d.* per hour, one third of what would be required for gas, were it used. A shed at the sugar-refinery of Messrs. Henry Tate & Sons, Silvertown, is lighted by a Crompton lamp in the ceiling, assisted by a canvas reflector. The whole of the shed is well lighted—four or five times more strongly than with gas—and the light penetrates an adjoining shed. The cost for fourteen hours of illumination is 1*s.* 9*d.*, or 1½*d.* an hour; the cost of illumination by gas was 3*s.* 6*d.*, or 3*d.* an hour. At the ship-building dock, Barrow-in-Furness, a work-shed is lighted by Brush lights at £4 14*s.* a week, where oil blast-lamps were formerly used at £8 9*s.* a week; and the erecting-shop, formerly dimly lighted by gas at £22 a week, is now efficiently lighted by electricity at half the cost.

DEGENERATION.

BY DR. ANDREW WILSON.

IN groups of the animal series, both nearly allied to the crustacean class and far removed from it in structure, equally interesting and often curious examples of degradation may be found. The class of insects and the nearly related group, including the mites, spiders, and scorpions as its representatives, number in their ranks instances of degraded and degenerate forms. Among the insects which are parasitic in habits a notable absence of wings is discernible, and this

latter want is seen even in those cases in which one sex alone of a particular insect species assumes the habit in question. An excellent illustration of such a fact, and also of the extreme modification of form which may accompany the degeneracy of highly organized animals, is found in the history of the insects collectively known as *Strepsiptera*, and of which the genus *Stylops* is the best-known example. The male stylops (Fig. 13, *a*) is an active insect, possessing a

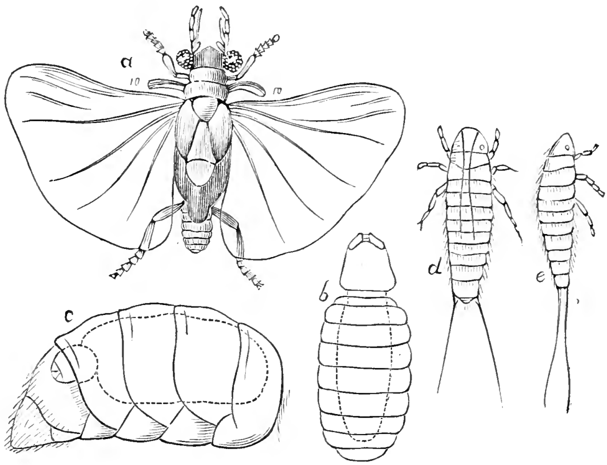


FIG. 13.—STYLOPS. (Fig. *c* shows the Stylops, in outline, within the body of the Bee ; and Fig. *b* shows the Stylops removed from the body of its host.)

single pair of wings. These wings are the hinder pair ; the front pair being represented by a pair of twisted organs (*w*), which illustrate wing-degeneration, possibly through disuse. Both males and females as they leave the egg are small, active, six-legged beings (*d*, *e*), which crawl about on the bodies of bees. Carried into the hive, the young stylops behave like the proverbial viper, injuring the community which gives them shelter by boring their way into the bodies of larval or infant bees. Here the young stylops, casting their skin, become in the larval interior sluggish, footless grubs. Each possesses a mouth, small jaws, and a digestive system of simple construction. Meanwhile, bee-development progresses ; and, as the larval bee passes through its chrysalis state with its stylops-lodger contained in its interior, the latter thrusts the front extremity of its body from between two of the hinder body-segments of the bee. Then the male stylops, undergoing development in this position, becomes the winged insect (*a*) and passes into the world. The female stylops (*c*), on the other hand, remain in their places on the bees. They undergo but a slight change of form, persisting as mere sac-like bodies (*c*), without legs or digestive system (*b*), and develop in their interior the eggs from which succeeding generations of stylops will be produced. Such a case of absolute degeneracy is all the more remarkable in view of the facts that it

is limited to one sex alone, and that the free-winged males of stylops are as highly organized as most of their neighbor insects.

The class of the spiders (*Arachnida*) offers collective examples of degeneration and retrogression, which show how large numbers of animals may acquire lower characters, contrasting with the higher phases to which other members of their class have attained. The mites and ticks have unquestionably originated from the same root-stock as the spiders and scorpions. The development of the two groups proves this much. But, while the latter animals have advanced to a high complexity of organization, the mites and ticks have degenerated into parasitic forms—or at least exemplify beings which, first attaining a respectable rank in their own series, have certainly not advanced upon that rank. Many of the mites, however, exhibit well-marked degeneration. Only on the hypothesis of sweeping retrogression can we account for the singular and anomalous condition in which a certain harmless mite, named *Demodex folliculorum* (Fig. 14), spends its existence. This mite inhabits the sacs or follicles of the human skin at the sides of the nose. It is a minute, worm-like animal, possessing eight degenerate rudiments of legs, and a thoroughly rudimentary structure in other respects. Here parasitism has denuded the

Fig. 14.—Demodex (magnified).

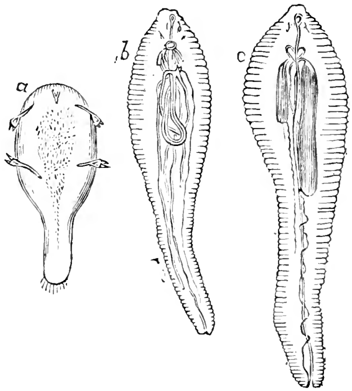


Fig. 15.—Linguatulina.

animal of wellnigh every attribute of its Arachnidan character, and has left it in a condition analogous in many respects to sacculina itself. Of the equally curious *Linguatulina* (Fig. 15), inhabiting the "frontal sinuses" or forehead spaces of dogs, wolves, horses, and sheep, the same remark holds good. The body here is thoroughly worm-like in shape (*b*, *c*), and a digestive and nervous system are to be enumerated among the possessions of the organism. But not even the rudiments of legs are to be perceived, although the mouth bears certain apologies for the appendages proper to that region in the mite and spider class. Yet the young linguatulina (*a*) exactly resembles the early form of the

mites. It possesses two pairs of jointed limbs, and certain style-like organs pertaining to the mouth. There is thus the clearest evidence that linguatulina is a degraded animal. It is the degenerate descendant of a free-living and apparently four-legged—or it may be eight-legged—ancestor; and its further history seems to afford a clew to the causes of its retrogression. For the four-legged larvæ of linguatulina escape, while still within the egg, from the nose of the dog or sheep host which has harbored their parents. Received along with food into the body of the hare or rabbit, the larval being liberates itself. From the rabbit's digestive system it bores its way through the tissues to the liver, thus reminding one strongly of the similar migrations of the embryo tapeworm. In the liver further changes ensue. Frequent moltings become the order of the day, and at length they assume a worm-like aspect and remain thus, still imperfect, until, by transference to the body of dog, wolf, or sheep, and by passage to the frontal sinuses, they acquire perfection of their life-functions. If the history of these beings teaches us anything concerning their past, it points to a free and active state as their original condition, and to the probable acquirement, first, of a lodgment in the digestive system of one animal as a relatively simple parasite; and, secondly, of a further modification of habit, transferring at once its perfection and completed degradation to the forehead cavities of a second host.

But the conditions which make for the degeneracy of an animal are, as we have seen in the case of the barnacles, not always associated with a parasitic habit. Mere fixation, as we have observed, secures the disappearance of useless organs, such as organs of motion and sense-organs, which, being possessed by the young form, clearly indicate that the ancestry of the animals in question has at any rate been capable of leading to better things than the descendants represent in their existent persons. The sea-squirts, or ascidians, besides serving as a text for the derivation of vertebrates, and for abnormal ways in the animal chemistry which imitates the plant's work, have been selected as fruitful objects of discussion by those biologists who find in the idea of degeneration an explanation of knotty points in natural history. For the same voice that proclaims the fact that a sea-squirt —which is a mere rooted bag with a double neck (Fig. 16)—begins life as a free-swimming, tadpole-like larva (Fig. 17, 5), tells us in the same breath that there must have been retrogression and degeneration from an active condition to produce the sac-like adult state. The assertion that the youthful sea-squirt, moreover, possesses first a rod-like body—called the *notochord* (Fig. 17, *n*)—only found besides in the young of vertebrate animals, is also to be taken as implying the superiority of ascidian infancy to sea-squirt maturity. And, when it is added that the elderly squirt wants the sense-organs and nervous cord which the larva possesses, it may well be argued that sheer degeneracy of habit and structure can alone account for the sweeping transformations

which mark the phases of ascidian life-history. Thus it is matter of sober, natural-history fact that a sea-squirt larva, of all invertebrate animals, is the only being that possesses organs and parts proper to the young vertebrate or to the *adult* form of one lower vertebrate in

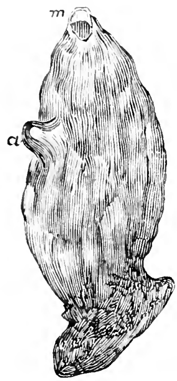


Fig. 16.—Sea-Squirt.

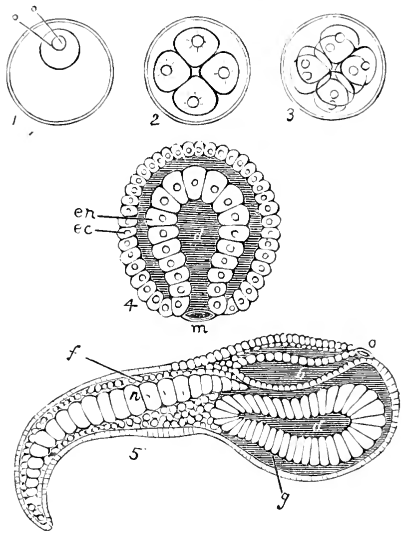


Fig. 17.—Development of Sea-Squirt.

particular. This adult is the little fish known as the lancelet, which, in the relative simplicity of its organization, makes a nearer approach to the poor or sea-squirt relations of the vertebrates than any other fish.

The fact of vertebrate and sea-squirt relationship is worth dwelling upon, because the topic unquestionably presents one with a common point of view, whence a survey of the higher development, evolution, and progress of the vertebrates, and a view of the degeneracy and retrogression of the sea-squirts, may best be obtained. Reveling in the freedom of its early life, the larval sea-squirt—presenting, as already noted, a striking resemblance to the tadpole of the frog, in its backbone, its nerve-system, and its breathing-sac, or modified throat—ultimately settles down. Like the youthful barnacle somewhat, the young sea-squirt attaches itself to a stone or shell by the suckers with which nature has provided its head. Then succeeds the disappearance of the tail, with its backbone and its nerve-cord, and the body itself soon assumes the sac-like shape that betokens the mature ascidian character. The outer skin becomes tough and leathery, and develops the *cellulose* which, by biological right, we should expect to find in plants alone. Then succeeds the fuller formation of the gill-sac or breathing-chamber, and of its neighbor compartment, which receives the effete water of respiration to be ejected by the second mouth of the sac-like

body. The eye of the larva likewise disappears, and all that remains to the adult ascidian is a nerve-mass, called by courtesy the "brain," and which serves to regulate the few acts that mark the placid and rooted existence of the race. Attention has been recently directed in a special manner to the resemblance which exists between the eye of the larval sea-squirt and that of vertebrates—a statement to be taken along with that which conversely declares the unlikeness of the ascidian eye to that of all other invertebrate animals. It is matter of fact that the chief parts of the eye of a vertebrate animal grow inward as developments from the skin, and unite with an outgrowth from the brain. This outgrowth forms the *retina*, a nervous network of the eye, whereon the images of things seen are duly received for transmission to brain and sensorium. Now, in invertebrate animals the retina is formed from the skin-layer. This latter method of growth, it has been remarked, is a perfectly natural one. It was to be expected that, as the retina is to be affected in the discharge of its duty by light-rays, it should form on the surface of the body where the light-rays fall. In the vertebrate, and in the sea-quirt larva, the retina, on the contrary, forms away below the skin-surface, and grows outward from the brain. Why is this so? Professor Ray Lankester maintains that because the ascidian larva is perfectly transparent, the light-rays pass through to its brain-eye, and thus give rise to sensations of sight. Hence, if the original and primitive vertebrate animal or root-stock were like the larval sea-squirt, as we suppose it to have been, its body would be transparent, and its eye or eyes, situated on its brain, would receive light-rays through its clear body. But, as the evolution of the vertebrate race proceeded, the tissues became firmer and denser. By "natural selection"—or, in other words, by the exercise of accommodating power to function—the eyed region of the brain would tend to grow more and more toward the body's surface, to receive the rays of light. As development, therefore, proceeded, the mode of growth of the vertebrate eye would be adapted to the exigencies of its new surroundings. Thus, to-day, the vertebrate eye grows from without inward, because light-rays strike naturally on the outer surface of the body. But it likewise grows from within outward as well, because of the ancestral and hereditary tendencies which cause it to repeat in the individual growth the passage to the surface it had to make in the evolution of the race. If one might add a suggestion to such an explanation, it would consist in an endeavor to account for that affinity between brain and outer surface of body which we see to exist. Why the brain should grow outward, as it does in eye, ear, and nose likewise, to connect with the body's surface, and so to form organs of sense, is plain enough. We must bear in mind that the brain itself is formed from the outer layer or *epiblast* of the larva, and from the same layer which develops into the skin. Brain and skin, to begin with, arise from the same layer. Hence, before even the matter of

eyes falls to be considered, the affinity of the skin-layer and the nervous system is a fact worth noting. It is this truest of relationships which may reasonably enough explain, not merely why the sense-organs arise from the skin-surface, but also why the brain grows outward to meet with the structure to which it is so near akin.

Degeneration of a very pronounced kind thus accounts for the peculiarities of sea-squirt structure to-day. The case of ascidian retrogression is likewise the more interesting, seeing that its reverse side is that of progressive evolution and development of the highest forms of life the existing world knows. It is, therefore, important to note in passing that the possibilities of development may include degeneration of a very marked type, along with progressive evolution of equally pronounced kind. The category of life's extension includes, in fact, many possibilities which at first sight might appear of most unlikely kind ; and, among these possibilities, that of extreme degeneration is by no means the least notable as an element in inducing the material variety of life we behold in the animal and plant worlds of to-day. The list of causes which lead to the degeneration of living beings includes, however, other fashions of producing retrogression than by fixation and parasitic habits, and operates in different ways upon organisms of varied structure and social or biological rank. Changes in food and feeding may thus accomplish degeneration and induce physiological backsliding of the most typical description. It is a familiar fact that the animal organism is of relatively higher nature than the plant, seeing that the animal frame can, as a rule, feed upon and build up its tissues from organic or living matter only. Animals, in other words, demand the substance of other animals or of plants, or of both combined, as a necessity of their commissariat arrangements. Plants, on the other hand, are specially constructive and elaborative in their feeding. They build up from the non-living matters around them—carbonic acid, water, ammonia, and minerals—the tissues of their living bodies. They "transubstantiate" this non-living matter into living tissue ; and the verdant tints of spring, the full glory of the summer's blossom, or the mellow ruddiness of autumn's fruits, represents, each in its way, the result at once of the plant's constructive chemistry and of the elaboration into living matter of the inorganic materials of air and soil around.

The animal frame, therefore, presents us—amid exceptions to the above rule in both animal and plant series—with relatively greater complexity of organs and tissues than the plant-body presents. This statement simply reëchoes what commonplace observation daily demonstrates. Hence, it may be a natural enough inference that whatever causes tend to bring the animal feeding nearer in type to that of the plant will tend to simplify animal structure, and so to produce retrogression and degeneration of the animal type. Many animals are thus known to develop *chlorophyl*, or the green color we see charac-

teristically in every leaf. Through the combined operation of this green color—either singly or aided by the leaf-protoplasm—and the action of light, plants decompose the carbonic acid of the air, as every schoolboy knows, and, retaining the carbon to aid in the formation of

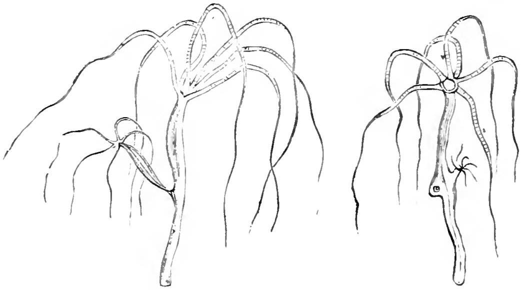


FIG. 18.—HYDRÆ. (In both figures young hydræ are represented budding from the side of the parent).

starch, set free the oxygen, which thus returns to the atmosphere, and is welcomed by the animal hosts. The hydra, or common fresh-water polyp (Fig. 18), many animalcules, and certain worms of a low type, possess this chlorophyl. Like dishonest manufacturers, they seem to have infringed the patent-rights of the plant to elaborate this green color. And it is no longer matter of theory, but ascertained fact, that these green animals are capable, like the plants, of absorbing carbonic acid—usually a fatal gas to the animal constitution—and of elaborating starch therefrom like their plant neighbors. Thus a simpler mode of feeding, obviating the necessities of animal existence in the way of digestive apparatus, has apparently led to the simplification of structure. Degeneration has followed in the worms just mentioned, as the result of their imitation and acquirement of vegetative powers of feeding; and it is probable that other alterations in the way of dietary, of less sweeping character than that just mentioned, will affect, in like retrogressive fashion, the animal constitution.

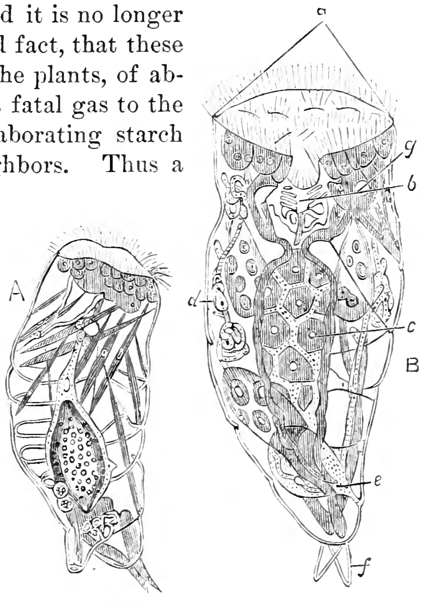


FIG. 19.—ROTIFERA.

Some of the most curious cases of degeneration known to us illustrate the total disappearance of digestive apparatus even in some beings, in which, as in the stylops already mentioned, one sex becomes

retrogressive while the other sex remains structurally fully developed. Such a case is illustrated by the males of those remarkable organisms, the *Rotifera*, or "wheel-animalcules" (Fig. 19). These minute creatures, inhabiting our fresh waters, may be desiccated and dried, and revived, on the application of moisture, many times in succession. But in their ordinary existence, and in the details of their structure, the "wheel-animalcules" present details equally interesting with their exhibition of "potential vitality." The female animalcules possess a complete digestive system, a set of water vessels, a nervous ganglion, and other belongings; but their partners are decidedly inferior creatures, since their digestive system becomes totally abortive, while in size the males are likewise far excelled by the lady rotifers. How this degeneration and disappearance of digestive apparatus and the inferiority of size have been produced in the male rotifers may be a matter regarding which difference of opinion will certainly exist in biological minds. The fact that retrogression is here illustrated, however, can not be questioned. It may also be added that, in all probability, the extreme development of the function of perpetuating the species and the extraordinary fertility of production witnessed in these animalcules, may satisfactorily account for the abrogation of digestion in favor of reproduction. Thus, to the other causes of degeneration in animal life and structure, we may append that which takes origin from the extreme or excessive development of one function over another. Physiological development in one direction, overstepping the natural and ordinary limits, runs concurrently with destruction of life's equilibrium, and naturally tends to produce degeneration and simplification of other organs and other duties of life.

How far the theory of degeneration we have thus briefly discussed may be applied in explanation of the peculiarities of animal structure, remains as a task for the future of biology to satisfactorily determine. Possibly the corrections which the future of every hypothesis carries with it may be many and sweeping. The deductions and inferences we extract from a study of degeneration to-day may perchance be falsified by the higher and newer views of the to-morrow of biological science. But enough has been said to show that, even in a cursory review of the doctrine of degeneration and retrogression, many phases of living histories become theoretically plain; and it argues hopefully for the correctness and value of the doctrine before us that it has, so far as it has been logically pursued, fitted compactly and harmoniously enough with ascertained facts and with received views of the origin of animals and plants. That higher forms of life than the sea-squirt and insect race are by no means exempt from the influence of retrogressive change is an observation worth noting at the close of our researches. We know, for instance, of lowly structures in shell-fish life appearing in the midst of highly organized frames. A mussel, a cockle, or an oyster, whose early development runs in parallel lines

to that of the snail and whelk class, is nevertheless esteemed less highly organized than the latter. The mussel or oyster tribe possess no head; the snails and their allies, as every one knows, not merely exhibit a well-developed head, but have that extremity provided with eyes, tentacles or feelers, and other addenda of the front region of the animal body. Hence it is more than probable that the mussel, headless and inclosed in its shell and possessing relatively little interest in the affairs of the outer world, is an example of a degenerated type of mollusks. The mussels and their relations stand, in fact, at the opposite extreme of development in this respect from those well-known mollusks, the cuttle-fishes. In these creatures, the tendency to head-development—or what Professor Dana calls "cephalization"—reaches its maximum, as any one may readily enough suppose on looking at an octopus or squid, with its great head, its enormous eyes, and its nerves massed together to form a brain inclosed in a kind of skull. Even as compared with the earlier cuttle-fishes—whose shells, under the name of ammonites and the like, we find fossilized in large numbers—the squids and cuttles of to-day present, in the extreme development of head, a noteworthy advance. Thus, while the one molluscan tribe of mussels and their neighbors has degenerated and gone to its own lowly place in the series, other groups, starting on an equal footing, have advanced, and, through progressive evolution, have produced those higher manifestations of molluscan life that teem in the seas of to-day. Even among the vertebrate animals we meet with examples of degenerative tendency which are not so easily explicable as the foregoing illustrations. In most snakes only one lung is fully developed, as a rule, the companion organ being rudimentary and degenerate. In birds, the egg-producing organs are similarly developed on one side only. How degeneration should be thus partial and affect one half of an animal's frame, so to speak, is very hard to discover. External conditions of life and the influences of surroundings could apparently possess little effect in inducing such an unsymmetrical retrogression of parts. Most probably we shall find the solution of such conditions to exist within the operation of some deep-seated law of the living constitution, and in the effects of that law in molding, or even contorting, the animal frame.

It constitutes one of the chief glories of biological science, as pursued among us to-day, that its studies are of far-reaching order, and lead, as the results of their natural extension, to the consideration of fields of thought often widely removed from the original topic which interests the reader. The present subject of degenerative changes, regarded as part and parcel of the living constitution, can readily be shown to possess applications far removed from zoölogy and botany, and extending into the most intimate spheres and phases of human history itself. Degenerative change in human tissues is medically symptomatic of very many of the ills to which flesh is heir.

Tissues and organs degenerate in individual animals, as animal frames retrogress in their entirety. Cells retrograde and fibers degenerate in our bodies, just as the sea-squirt's frame exhibits, as a whole, a universal, physiological backsliding. Nor may many of our diseases alone be esteemed mere examples of degeneration affecting our tissues. The termination and decline of life itself and the age that really "melts in unperceived decay" are, in reality, examples of natural degeneration also. The decline of existence is largely a retrogression of structure. There can be no such thing as a really "green old age," any more than we can speak of "the sere and yellow" of the autumnal leaf as imitating the verdant nature of the spring blossom. Nay, stranger still is it to discern that the full flush of life's vigor is accompanied by degenerative changes as typical as those which mark life's decline. For every tissue wastes as it works; and cells degenerate, die, and are cast off from every surface and tissue of our frames as the natural result of living and being. "Generally speaking," says a writer, in discussing the degeneration of human tissues, "those parts which live most slowly are those of which the duration is the greatest, and in which there is consequently the least frequent change. Of the exuviation of epidermic structures *en masse*—a process altogether comparable to the fall of the leaf—we have striking examples in the entire desquamation of serpents, the molting of the plumage in birds, and the shedding of the hair in mammalia; and, in the shedding of the antlers of the stag, we have an example of the exuviation of a highly organized and vascular part, which periodically dies, and which, being external, is cast off entire. 'What means all this,' says Sir James Paget, 'but that these organs have their severally appointed tissues, degenerate, die, are cast away, and in due time are replaced by others, which in their turn are to be developed to perfection, to live their life in the mature state, and to be cast off?'" And, again, the same high authority remarks that "it is, further, probable that no part of the body is exempt from the second source of impairment; that, namely, which consists in the natural death or deterioration of the parts (independent of the death and decay of the whole body) after a certain period of their life. It may be proved, partly by demonstration and partly by analogy, that each integral or elemental part of the body is formed for a certain natural period of existence in the ordinary conditions of active life, at the end of which period, if not previously destroyed by outward force or exercise, it degenerates and is absorbed, or dies and is cast out; needing, in either case, to be replaced for the maintenance of health." To these weighty words we may lastly add the opinion of Dr. Carpenter, who remarks that, "when the adult type has once been completely attained, every subsequent change is one rather of degeneration than of development, of retrogression rather than of advance."

Degeneration is thus an invariable concomitant of life. So far

from being in any way an abnormal phase of living action, it is seen to be as natural a process for living beings to retrogress—wholly, as we have seen in some cases, or partly, in others—as it is for them to develop and advance. And what is thus undoubtedly true of the individual man or other animal is no less so of the race. "Buried civilizations" are by no means unknown; extinct culture is an archæological fact; the decline and fall of nations are matters of history. May not these things be likewise explained as a part of that wide theory of life which regards even the highest interests of man as lying within the operation and sway of causes which mold his physical organization? If this notion be accepted, then is the idea of degeneration as a normal phase of life rendered still more feasible and plain. Reaching to the individual and to the species as well; extending and including in its scope the lowly organized as well as the higher being; affecting one group or class lightly, and influencing another wellnigh to the complete exclusion of progress, we find degeneration and retrogression to be numbered among the stern realities of existence. And no less clearly and forcibly may we trace the truly natural place of degeneration in our own physical history: since, as physiology teaches and daily experience declares, not an action is wrought or a thought conceived without the presence of change and decay of tissue—a process this which, limited in early life by progressive growth and by development, at last comes in our latter days to assume the reins of government, and in time to dissipate our energy and substance into the nothingness of physical and corporate extinction.

The philosophy of biology, however, may, in conclusion, be found to point out to us that the subject of degeneration, while treating of a powerful factor in modifying the living form, yet possesses a favorable aspect in relation to progress and evolution. High authority in matters biological may be found for the statement that degeneration is really a result of progress, that it is dependent on high development, and that, while it simplifies the living being, "it produces the same effect as differentiation, for it leads to variety in form." Thus there is a kind of evolution and progress inseparable even from degeneration itself. For the retrogression may in itself lead to variety and change, and in due time such variety may be the starting-point of new and higher developments. So, likewise, we are reminded that reduction and degeneration of some parts may proceed contemporaneously with the higher development of others, with the total result of perfecting the organism and of evolving a higher type of structure. The degeneration of a frog's tail is in reality a feature of its higher type as compared with its tailed friends, the newts and salamanders. The disappearance and reduction of the tail which the young crab possesses is a chief reason why we esteem the crab, whose body is all head and chest, a higher animal than the lobster or prawn, with head, chest, and tail complete. The degeneration of the "outside" gills of the Alpine

salamander's young, which never have access to water, is not a mark of inferiority but of superiority; it is, in reality, the casting off of the old or larval and aquatic characters and the putting on of the new and higher features of the land-animal. Even the degeneration of human structures—the modification of the tail which early human existence exhibits, and of muscular structures well developed in lower life—are no proofs of inferiority, but are evidences of superiority in ourselves. Thus, even in the great work of evolving higher races out of the lower, to degeneration much is owing for its aid in repressing larval characters and the structures which belong to lower existences. While progressive evolution develops the great tree of life, extends each branch, clothes it with verdure, and expands each blossom, it is degeneration which lops the worn and aged stems, prunes the weakly foliage, trims the budding growths, and so directs and molds the outlines of the organic whole. It is to evolution and progress that the world of life largely owes its forward march. But hardly less is the debt of gratitude due by the living hosts to degenerative change and retrogression which, though stern and ofttimes cruel in their ways, nevertheless mark wisely and well the pathways of life, and prevent the useless and weak from cumbering the ground.—*Gentleman's Magazine.*

THE PHENOMENA OF DEATH.

By THOMAS D. SPENCER, M. D.

THERE seems to be no subject from which the mind so instinctively shrinks, few thoughts more repellent to the soul, and no dread vision of the night, howsoever fantastic it be, that presents to the imagination so formidable an aspect as that of death. Indeed, with this all nature seems at variance. The English ivy creeping over fallen ruins, or the fresh moss covering the prostrate trunk of some forest oak, seems as if endeavoring to hide from view the havoc which death has made. Beyond the merely instinctive desire to exist, the dread of death is a matter of education. Never does the child forget his first sight of a corpse; the darkened chamber, the storm of grief, the white face and rigid features, all combine to form an indelible impression on the mind.

It is probably the extensive paraphernalia attending the funeral of the present day that render death so formidable. In war—on the battle-field, where death assumes its most sanguinary aspect—the mind of the soldier, from constant association, becomes so inured, that it ceases to be impressed with natural terror, and death seems but another foe to be met and conquered. Although the consideration of this topic be repugnant to the naturally healthy mind, there

come times in the life of every individual, that might be termed periods of self-consciousness, during which the mind brushes aside the more vulgar affairs of life, and grapples with the awe-inspiring mysteries of death. As these phenomena are considered one after another in their manifold aspects, the mind, owing to the association of ideas, becomes involved in such an intricate labyrinth of thought, that, after wandering here and there, vainly endeavoring to solve the problem of death, it gives it up as a hopeless conundrum.

It is our purpose to discuss, as briefly as possible, some of the most important aspects of dissolution.

Addison said that there was nothing in history more imposing than, nothing so pleasing and affecting as, the accounts of the behavior of eminent persons in their dying hours; and Montaigne remarks, while speculating on death, that of all the passages in the annals of mankind those which attracted and delighted him most were the words and gestures of dying men. "If I were a maker of books," he continues, "I would compile a register with comments of various deaths, for he who should teach men to die would teach them to live." There are three elements presented in this fear of death: First, the extinction of life's pleasures, interests, and hopes, to which the mind looks forward with a degree of apprehension, proportionate to the amount of happiness they are capable of affording. With the young and vigorous the loss of these animal enjoyments is contemplated with extreme misery; hence the custom, among the early Greeks, of bearing the lifeless body of youth to the funeral-pyre at the break of morn, "lest the sun should behold so sad a sight as the young dead." Second, the dread of the unknown future, also depending upon the nervous temperament. And, lastly, comes a fear more powerful than either, which is the dread of pain, inherent in nature. From time immemorial the actual moment of dissolution has been supposed to be accompanied by a throe of anguish known as the "death-agony." This is believed to occur at that moment when the spiritual and physical forces that have been so intimately blended for many years are torn asunder, the one to molder and decay, the other to take upon itself that new life beyond the ken of man.

This last element properly belongs to the physiologist, and as such we propose to consider it. Sir Francis Bacon, in one of his essays, published for the first time in the year 1577, gave to the world the following profound thought: "It is as natural to die as to be born, and to the little infant, perhaps, the one is as painful as the other." In profundity of thought and depth of research Bacon stepped in advance of his contemporaries, and lived in the future. Thus we find that, contrary to the generally received opinion of even this latter day, Nature evidently designed that the end of man should be as painless as his beginning.

At birth the babe undergoes an ordeal that, were he conscious,

would be more trying than a most painful death ; yet he feels it not. Born in an unconscious state, the brain incapable of receiving conscious impressions, his entrance into this hitherto unknown world is accomplished during a state of oblivion, known as Nature's anæsthesia :

> "Painlessly we come, whence we know not—
> Painlessly we go, whither we know not!"

From the earliest period of human history death has been considered as necessarily accompanied by pain ; so general is this belief, that the terms "death-agony," "last struggle," "pangs of death," etc., have been in almost universal use in every age and under all conditions of society.

Nothing could be more erroneous ; the truth is, pain and death seldom go together—we mean the last moments of life. Of course, death may be preceded by weeks or even months of extreme suffering, as occurs during certain incurable diseases.

So exaggerated has been this notion that it has been considered an act of humanity to anticipate the "death-struggle" by violence ; for ages it was customary among the lower classes of Europe to hasten death by suddenly jerking the pillow from beneath the head of the dying, thus throwing the head backward, straining the pharyngeal and thoracic muscles, rendering the respiration, already difficult, shortly impossible. A Venetian ambassador, in the time of Queen Mary, asserted that it was a common custom among the country-people to smother the dying by means of a pillow placed over the face, upon which leaned or sat the nearest relative. This was founded upon the pious belief that a short road was the best one. This custom was handed down from generation to generation, parents performing it for their children, and *vice versa*. But, perhaps, the saddest privilege ever allowed the near friends of a dying man, occasionally occurred during the reign of Queen Elizabeth, when through executive clemency—in executions by hanging—they were permitted to grasp the feet of the suspended criminal, and, by clinging to the extremities, precipitate their additional weight on the body, thereby hastening strangulation. It is needless to say that these theories are false in both conception and practice. Death is a physiological process, and like all other animal functions should be painless.

When the fiat of death went forth, Nature kindly provided an anæsthetic for the body. As the end of life draws near, the respirations become slow and shallow, interrupted now and then by a deep, sighing inspiration, as though the lungs were vainly endeavoring to throw off the palsy creeping over them. As the intervals between the inspirations grow longer, the blood becomes saturated with carbonic-acid gas—the same as that formed from burning charcoal, whose deadly fumes have so often aided the suicide to painlessly destroy life.

While the power of breathing is gradually failing, the heart, which

is in close sympathy with the lungs, begins to contract with less force, propelling the blood only a short distance through its arterial channels, thus causing the extremities to grow cold.

The blood sent to the brain is not only diminished in quantity, but is laden with carbonic-acid gas, which, acting on the nervous centers, produces a gradual benumbing of the cerebral ganglia, thereby destroying both consciousness and sensation. The patient gradually sinks into a deep stupor, the lips become purple, the face cold and livid, cold perspiration (death-damp) collects on the forehead, a film creeps over the cornea, and, with or without convulsions, the dying man sinks into his last sleep. As the power of receiving conscious impressions is gone, the death-struggle must be automatic. Even in those cases where the senses are retained to the last, the mind is usually calm and collected, and the body free from pain.

"If I had strength to hold a pen, I would write how easy and delightful it is to die!" were the last words of the celebrated surgeon, William Hunter; and Louis XIV is recorded as saying with his last breath, "I thought dying had been more difficult."

That the painlessness of death is due to some benumbing influence, acting on the sensory nerves, may be inferred from the fact that untoward external surroundings rarely trouble the dying.

On the day that Lord Collingwood breathed his last, the Mediterranean was tumultuous; those elements which had been the scene of his past glories rose and fell in swelling undulations, and seemed as if rocking him asleep. Captain Thomas ventured to ask if he was disturbed by the tossing of the ship. "No, Thomas," he answered, "I am now in a state that nothing can disturb me more—I am dying; and I am sure it must be consolatory to you, and all that love me, to see how comfortably I am coming to my end." In the "Quarterly Review" there is related an instance of a criminal who escaped death, from hanging, by the breaking of the rope. Henry IV of France sent his physician to examine him, who reported that after a moment's suffering the man saw an appearance like fire, across which appeared a most beautiful avenue of trees. When a pardon was mentioned, the prisoner coldly replied that it was not worth asking for. Those who have been near death from drowning, and afterward restored to consciousness, assert that the dying suffer but little pain. Captain Marryat states that his sensations at one time when nearly drowned were rather pleasant than otherwise. "The first struggle for life once over, the water closing round me assumed the appearance of waving, green fields. . . . It is not a feeling of pain, but seems like sinking down, overpowered by sleep, in the long, soft grass of the cool meadow."

Now, this is precisely the condition presented in death from disease. Insensibility soon comes on, the mind loses consciousness of external objects, and death rapidly and placidly ensues from asphyxia.

In spite of the natural antagonism to death, a moment's reflection will show that it is as much a physiological process as life; the two terms are correlative, the degree of vital activity depending on the extent of molecular death occurring at the same time. Strange as the paradox may seem, without death we can not live: every thought emanating from the brain, every blow struck by the arm, is accompanied by destruction of nervous or muscular tissue. The bioplasmatic or living matter of Beal, which enters into the formation of every animal tissue, is constantly germinating into cells (the origin of all life), and as constantly passing into decay, their places being taken by other protoplasts, thus keeping up the "active dance of life."

This disassimilation or interstitial death occurs to such an extent, that Nature, in her wisdom, has provided excrementory organs for the purpose of removing from the system the effete material thus produced. Every living structure, after passing through certain stages of development, maturity, and finally retrogression, must come to an end. This may be but the ephemeral existence of some of the lower forms of fungi, which, born in the cool of the morning, die as the sun goes down; or, like the famous dragon-tree of Teneriffe, may outlast the Pyramids that keep watch by the Nile.

The last topic for consideration is the *pseudopia* of death, or visions of the dying. This subject, coming under the realm of mental science, properly belongs to metaphysics rather than to physiology. Various theories have been advanced to explain these phenomena, but they must remain as hypotheses at best, for they are not susceptible of demonstration. It is not an uncommon occurrence for the dying, after lying some hours in a semi-conscious condition, to start up suddenly, and, with glowing face, point eagerly to some object invisible to the bystanders, and with animated voice and gesture state that they behold the glories of heaven, or the familiar countenance of some friend long since dead.

The question naturally arises as to whether these visions are merely the fantasies of a disordered and fast-disorganizing brain; or are the dying actually permitted a momentary view of those mysteries hitherto unknown?

The traditions and superstitions of the past have led to a popular belief in the latter theory. Shakespeare expressed the sentiment of his day when he placed in the mouth of the dying Queen Katharine these words:

> "Saw you not even now a blessed troop
> Invite me to a banquet, whose bright faces
> Cast thousand beams upon me like the sun?"

Science, with its iconoclastic hand, has swept away these pleasing fancies, and in their places has constructed a fabric founded on analo-

gy. In the anæsthesia induced by chloroform, a condition is produced closely resembling that immediately preceding death (caused by the carbonic-acid poisoning), in which visions are constantly presented to the mind, the character of which depends upon the natural temperament of the individual. Thus it often occurs that a patient, when under the influence of chloroform, has beatific visions similar to those of the dying. It is my fortune to have at present a patient who invariably, when under the influence of chloroform, asserts that she sees angels hovering round her bed. The impression is so strong that she becomes much annoyed if the reality of these visions is disputed. The asphyxia produced by burning charcoal is ofttimes accompanied by disturbed fancies, similar to those preceding death, and the natural inference is that they are the resultant in both cases of one and the same cause. During the last moments of life, the mind gradually loses cognizance of external surroundings, and is rapt in self-contemplation. Though still in a semi-conscious condition, the weeping of friends and the voices of attendants fall upon dull ears. The eyelids are closed, the pupils slightly contracted, and rolled upward and inward. The dying man has forgotten the present, for he is living in the past. One by one the events of a whole life appear, its joys and sorrows, perchance long since forgotten, rise before him in startling distinctness, and then disappear in the swiftly moving panorama. The familiar faces of the friends of his youth are thrown upon the mental retina, their cheery voices reverberate in his ears, and the thought of meeting these friends in the near future is perhaps his last conscious impression. As this drowsiness creeps over the system, these images, molded from the past, become as realities to the disordered imagination. The germs from which originate these strange combinations have probably been lying dormant for years in the registering ganglia of the brain.

Dreams never surprise us, no matter how strange the scenery presented, or how great the violation of truth and reality: so it is in this last great vision of life. What wonder that a dream so vivid should be carried into action? The brain, with a convulsive effort, sends the message through the system, the muscles spring into activity, and the dying man, with outstretched arms, calls the attention of the awe-stricken bystanders to these fantasies of his own brain. Thus some pass away as though falling asleep; others with a sigh, groan, or gasp; and some with a convulsive struggle.

These death-bed visions are comparatively of frequent occurrence, and are generally accepted as realities. The theory which we promulgate, though not new, will naturally excite prejudice; but it is better to know the truth than to cherish a belief, however pleasing it be, founded on error.

UNION OF THE TELEGRAPH AND POSTAL SERVICE.

By ALDEN B. HUET.

THE recent consolidation of competing lines of telegraph into one gigantic corporation, and the consequent agitation of the question of Government control by the public press, Boards of Trade, and in Congress, make an inquiry into the subject of postal telegraphs, at the present time, of unusual interest.

In determining the question as to whether the United States should constitute this means of communication a part of the general postal system, the first important consideration is, whether such action is authorized by the Constitution; secondly, whether such control has proved a success in the several countries where it is thus organized; and, finally, whether a beneficial result is likely to follow from similar action in this country.

As to the first proposition, there can be no doubt. That clause of the Constitution wherein this authority is granted is found in section 8 of Article I, in this language: "Congress shall have power . . . to establish post-offices and post-roads." By this comprehensive and explicit declaration, the framers of the Constitution, without doubt, intended to lodge with the General Government the exclusive privilege of regulating and conducting the transmission of intelligence among its citizens—in other words, the intent was to give to the General Government the exclusive monopoly of the postal service, by which was meant the interchange of intelligence, not only by the methods then in use, but also by the use of improved methods thereafter devised and adopted. This opinion is sustained by the decision of the Supreme Court in the case of The Pensacola Telegraph Company *vs.* The Western Union Telegraph Company (6 Otto), in which the Court says: "Post-offices and post-roads are established to facilitate the transmission of intelligence. Both commerce and the postal service are placed within the power of Congress, because, being national in their operation, they should be under the protecting care of the national Government." That these views are sound is too plain to be doubted. Continuing, however, the Court touches upon the very point in question—the telegraph: "The powers thus granted are not confined to the instrumentalities of commerce, or of the postal service, known or in use when the Constitution was adopted; but they keep pace with the progress of the country, and adapt themselves to the new developments of time and circumstances. They extend from the horse with its rider to the stage-coach, from the sailing-vessel to the steamboat, from the coach and steamboat to the railroad, and from the railroad to the telegraph, as these new agencies are successively brought into use to meet the demands of increasing population and wealth. They were

intended for the Government business to which they relate, at all times and under all circumstances." It was impossible for the men who framed the Constitution to foresee the wonderful improvements in the means of rapid intercommunication which have since taken place. At that time there were only a few post-roads in the United States, and over these the mails were conveyed on horseback or in the stage-coach, consuming a fortnight in the trip from Boston to Philadelphia, that is now made by the fast mail in a few hours. In the progress of events, the people demanded a quicker means of communication, and the Government did not hesitate to place the mails upon the railroads as fast as they were constructed. Now, in many instances, the railroads are too slow to meet the demands of business communication, and the telegraph is freely used in all important commercial transactions. The business-man who does not use the telegraph each day for information as to markets abroad, to make contracts with distant customers, to transmit money, and in various other ways, is counted slow indeed in this age of progress. From these facts, is there not the more reason for making this wonderful and powerful agency subservient to the general postal system of this great and growing country than there was for providing for the carriage of the mails by steam?

Further, it is not only a constitutional privilege, but it is also a constitutional duty; and it is susceptible of the strongest proof that, in neglecting to make the telegraph a part of the postal system, the Government has failed of its constitutional duty toward its citizens. Such powers as are granted to the General Government are granted absolutely, and are lodged nowhere else. In the language of the tenth amendment, "The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people." It may not be improper to observe here that only such powers were granted to the General Government as could not properly be exercised by the States. For instance, the right to declare war was granted to the General Government, and wisely, else New York might declare war against some foreign power, while the remaining States might be strongly in favor of peace. It is, therefore, fair to infer that such powers as were granted to the General Government were not "reserved to the States respectively, or to the people"; and in this class, as we have seen, is the power to regulate and control the transmission of intelligence. In the language of Mr. Justice Field, in *ex parte* Jackson (6 Otto), "The power possessed by Congress embraces the regulation of the entire postal system of the country." It extends to the telegraph as well as to the railroad, and the conveyance of letters and packets by regular trips over railroads by private parties is prohibited by law (Revised Statutes, sections 3,982, 3,983), yet we permit a private monopoly to convey our messages the quicker way by telegraph. The Government enforces a monopoly of the transmission of intelligence by the slower methods,

but when the lightning is invoked that is left to the monopoly of a single private corporation, contrary to the true intent of the Constitution.

Let us now see what success has attended the postal telegraphs of other countries, which have been quick to shed the blessings of an American invention upon their citizens, under the protection afforded by Government control. Among the first to adopt this system was the Government of Belgium, where, March 15, 1851, it was established with a tariff of two and one half francs for twenty words within a radius of seventy-five kilometres, or fifty cents for a distance of forty-six and one half miles, and five francs for a distance above seventy-five kilometres. The "registered system" was adopted here by which the sender, upon payment of a double fee, was provided with an exact copy of the message delivered to his correspondent, together with the exact time of the delivery. In 1878 the tariff had been reduced to a fraction over eight cents for each twenty words, and the receipts from this source amounted to $426,258.84. The next year, December 5, 1852, Switzerland adopted the system with the following tariff: for a message of twenty words, one franc; over twenty and under fifty, two francs; above fifty, three francs. In this country, almost from the very first, the receipts showed a large surplus over expenditures, and this was augmented in 1868, when the tariff was reduced to one half a franc for twenty words—a uniform rate. In 1879 the receipts amounted to $400,763.04; expenses, $314,893.39. About the same time the system was introduced in France, where it proved a complete success from the first. In 1877 the French tariff was a fraction over sixteen cents for twenty words, and the receipts from this source were $3,203,800. Then followed Russia, Germany, Sweden, Italy, New Zealand, and other countries, with the most gratifying results in each case. Great Britain, usually so quick to adopt reforms in the postal service, and to which Government we are indebted for various improvements in our service—the postage-stamp, money-order, postal-car, carrier-system, postal-card, etc.—was the last of the European countries to establish the system. Previous to its introduction there, the Chambers of Commerce memorialized Parliament in favor of the measure, alleging that they "had reason to complain not only of the high rates charged by existing companies for the transmission of messages, of frequent and vexatious delays in the delivery, and of the inaccurate rendering, but that many important towns, and even whole districts, are unsupplied with the means of telegraph communication." In moving leave to introduce the postal telegraph bill, the Chancellor of the Exchequer said: "We were in the habit in this country of leaving to private enterprise the administration of internal affairs, the exception to the rule being that of postal communication. With the consent and approbation of the country, this was a monopoly in the hands of the Government; and he submitted that telegraphic com-

munication and postal communication might be considered as coming within the same category, as both provided for correspondence between persons at a distance, and the only difference was the mode of communication. It would be admitted, as a general principle, that the monopoly which had succeeded so well in regard to the conveyance of letters might be expected to succeed equally as well in a more rapid method of communication. He was not aware of monopoly in the one case which would not hold good in the other." The reasoning of the distinguished Chancellor applies with greater force to this country, where the rates are higher than they were at this time in Great Britain, and where the entire telegraph system is in the hands of a single private corporation. The transfer of the telegraph business to the Government in Great Britain took place February 5, 1870, and in 1872 there was a net revenue from this source of £159,835, which increased in succeeding years. The following table exhibits the extent of telegraph business in the countries named :

COUNTRY.	No. of telegraph-offices.	Length of lines (miles).	Receipts.	Year.
Great Britain	5,254	115,460	£1,346,892	1879
France	2,895	35,445	$3,203,800 00	1878
Russia	2,166	59,012	3,046,539 08	1874
Switzerland	1,150	......	400,763 04	1879
Belgium	586	3,234	426,258 84	1878
Italy	1,795	14,750	1,451,088 64	1875

The conclusions deduced from the foregoing facts, as applied to the question of adopting such a system in this country, are:

1. That the Government has the constitutional right to own and operate lines of telegraph, as a part of the general postal system, to the exclusion of all private competition ; and, further, that such action is clearly a constitutional duty.

2. That in all the leading countries of the world the Government exercises this right, either in whole or in part, to the great benefit of the citizens of such countries, protecting them from the extortions of monopolies, and guaranteeing, for a small charge, to transmit and deliver their telegraphic correspondence with the privacy of sealed letters, with greater certainty and efficiency than can be assured by private corporations.

3. That there is no reason to doubt that the success which has attended the system in other countries would obtain here, especially when we consider the energy and enterprise of our countrymen, and the extent and resources of our great and rapidly developing country ; and that with a uniform tariff, say of twenty cents for twenty words or less, it could be made in a few years to cover all expense, if not (which is probable) a source of revenue to the Government. That the near future will witness this realization is quite certain.

SKETCH OF DR. CHARLES T. JACKSON.

THE name of Dr. CHARLES T. JACKSON deserves to be awarded a prominent place in the annals of American science. It is closely associated with the earlier geological investigations in the United States and the British Provinces, and with the initiation of discoveries which have contributed immensely to the increase of the economical resources of the world and to the amelioration of the pains of suffering men. However the balance of merit in the discovery of the electro-magnetic telegraph and of anæsthesia may be awarded, the fact that Dr. Jackson conceived the ideas which embody the principles of those discoveries, and probably imparted them to the more practical men who made them known to the world, can hardly be disputed.

Dr. Jackson was born at Plymouth, Massachusetts, June 21, 1805. Having studied medicine under Drs. James Jackson and Walter Channing, he entered the Medical School at Harvard University, and received its degree of Doctor of Medicine in 1829. He had already manifested an inclination toward other studies than those required in the practice of medicine, and became particularly interested in chemistry, mineralogy, and geology. Indeed, before receiving his degree, he explored, in company with his friend Mr. Francis Alger, a considerable part of the province of Nova Scotia, and made there a large collection of minerals; these being new to foreign cabinets, he was able, by means of exchanges with them, to form for himself a cabinet of great value.

Soon after receiving his degree he went to Europe to complete his studies, where he remained for three years. At Paris, he became acquainted with many eminent men, among them the celebrated geologist, Élie de Beaumont, with whom he formed a warm friendship that continued through life. In 1831 he made a pedestrian tour of a large part of Central Europe, visited the principal cities of Italy, and made a geological tour of Sicily, and of Auvergne, in France. It was while returning from his European residence, in October, 1832, having electro-magnetic, galvanic, and other philosophical apparatus with him, that he had those conversations with Professor Morse which he claims implanted in that inventor's mind the germs of the idea of the electro-magnetic telegraph. A year and a half afterward, in the spring of 1834, as he asserts, he constructed, successfully worked, and exhibited to his friends, a telegraphic apparatus similar to that the conception of which he claimed to have described to Professor Morse.

He settled in Boston, in the practice of medicine, in 1833, but in a short time abandoned his profession, so that he might give his whole time to the chemical, mineralogical, and geological investigations which he preferred. He soon became known as one of the leading

scientific men in the country. He was appointed State Geologist of Maine, and surveyor of the public lands of Massachusetts lying in Maine, in 1836, and spent three years in the execution of those works. In 1839 he, as State Geologist, surveyed Rhode Island; and he began the geological survey of New Hampshire, in which he was occupied for three years, in 1840. At about this time he drew up a plan for the geological survey of New York, which was adopted. He explored the southern shores of Lake Superior, and revealed the mineral resources of that country in 1844; returned to the same region in the next year, and opened copper-mines, and discovered iron-mines. In 1847 he was appointed to superintend the geological survey of the mineral lands of the United States in Michigan, a work in which he continued for two years, till he was displaced in consequence of political changes in the national Government. He became a member of the Boston Society of Natural History soon after its formation, and was elected one of its curators in 1833. He afterward became one of its vice-presidents, and continued to hold that office till disabled by sickness in 1874.

Dr. Jackson's name is most closely associated with his claim to priority in the discovery of the anæsthetic properties of ether, which was the subject of a long controversy, and one that was very painful to him. His claim is supported by the testimony of Mr. Francis Alger, Dr. J. B. S. Jackson, Dr. Martin Gray, and Mr. T. T. Bouvé, to whose eulogy before the Boston Society of Natural History we are indebted for most of the facts given in this notice. These gentlemen were his chosen friends, and were for a long time closely associated with him. Dr. J. B. S. Jackson was one of the signers of a remonstrance addressed to Congress against its making a grant of money to W. G. Morton, Dr. Jackson's rival in the claim of discovery, based upon the ground that the signers believed that the reward, so far as the question of discovery was concerned, ought to go to Dr. Jackson. Dr. Martin Gray published a pamphlet under his own name, maintaining that Dr. Jackson was the sole discoverer of anæsthesia, and that Mr. Morton could only be considered to have performed a secondary part by proving that the administration of ether is safe in surgical operations. Mr. Bouvé, who was for a considerable time a student in Dr. Jackson's laboratory, and afterward met him frequently in social intercourse, accords to him the honor of having been the discoverer of the anæsthetic properties of ether, but has "never thought him entitled to the credit of its introduction into use, or even to that of having thoroughly verified what he claimed to be true respecting the safety of administering it. He had experimented upon himself, and had afterward demonstrated respecting it, even going so far as to recommend its use by others, and this constituted discovery; but he did not prove to others what he was himself convinced of, and allowed precious time to pass—yes, much time—without making any application of the discovery. Indeed, had it not been that Mr. Mor-

ton sought from him means to prevent pain when extracting teeth, it is doubtful if the world would have had the advantage of the discovery for years, if ever. The truth is, Dr. Jackson was a great genius and had remarkable intuitive perceptions of scientific truths, but, from some peculiarities hard to comprehend, he often contented himself with enunciating what he recognized as fact, without striving to substantiate it. He himself admitted his shortcomings in this respect. When Dr. Gray had written his essay upon the discovery of ether, claiming for Dr. Jackson all the merits of its introduction, I objected to his view of the matter, and took the ground that the world was indebted to both Jackson and Morton for the great boon ; to one as the scientific discoverer and suggester of its use in surgical operations, to the other for his application of it and its practical introduction.

"Dr. Jackson, learning of this, upon meeting me remarked that I was thought not to be friendly to him in the matter. I then said: 'Doctor, you have known for a long period what Mr. Morton is now demonstrating to be true, but have allowed it to remain a dormant fact in your mind. If he had not sought information from you, might it not have remained so for years longer?' He answered that possibly it might. I think it may fairly be said that, without both Jackson and Morton, the world might have been none the happier for what either would have done ; one supplemented the other. To them together belongs the great honor of having served humanity beyond what language can express."

Dr. Jackson was the first person in this country to establish a chemical laboratory for students ; and many of the chemists of the last half-century were indebted to him for their earlier instruction in the analyses of mineral bodies. While engaged in giving instruction of this kind, he invented a powerful blast-lamp for alkaline fusions, which was very serviceable previous to the introduction of street-gas into laboratories.

His geological explorations of the three New England States and the south shore of Lake Superior were among the earliest that were made in the United States.

Dr. Jackson's scientific papers, which appeared from time to time in the public journals, were numerous ; many of them were of great interest and importance.

As early as 1834 he contributed to the "Journal of the Boston Society of Natural History" an article on the "Chiastolite or Macle of Lancaster, Massachusetts." This was followed by other papers on various minerals. The published "Proceedings" of the Society, from 1841 till the time when he was prostrated by illness, were illuminated by his frequent contributions to the discussions and papers on matters of scientific interest. To "Silliman's Journal" he contributed "Analyses of the Mineral Waters of the Azores"; "Remarks on the Geology

of Maine"; "Bituminization of Peat, and its Conversion into Coal"; "An Account of the Catlinite or Indian Pipe Quarry"; "The Lava of the Volcano of Kilauea in Hawaii, and its Chemical Composition"; "Remarks upon Drift and upon the Organic Matters of Soils"; "The Lake Superior Copper Region"; "The Asphaltic Coal of New Brunswick"; "The Discovery of Fossil Fish in the Coal Formation of New Brunswick"; and a few papers of more limited interest.

To the "Proceedings" of the Association of American Geologists he has furnished descriptions of the veins of tin-ore in Jackson, New Jersey, and "Remarks upon the Zinc, Copper, and Lead Ores of New Hampshire." To the "Proceedings" of the American Association for the Advancement of Science, "Observations of a Mirage seen at Lake Superior"; "Remarks on the Geology, Mineralogy, and Mines of Keneewaw Point"; "On Ancient Pot-holes in Rocks"; "Description and Analysis of Allanite from Franklin, New Jersey"; "Description of Bismuthic Tellurium from Virginia"; "On the Artificial Minerals from an Iron-Furnace in Pennsylvania"; and other papers. To the "Proceedings" of the American Academy of Arts and Sciences, "Remarks upon a Large Vein of Phosphate of Lime found in New Jersey"; "Analysis of Water"; "Analysis of Bornite from Georgia"; "Results of an Examination of the Frozen Well of Brandon, Vermont"; and "An Analysis of Meteoric Stone found in Dakota." To the Memoirs of the Academy he contributed, jointly with Mr. Francis Alger, a valuable paper on the "Mineralogy and Geology of Nova Scotia." Reports of analyses of soils made by him were published in the "American Quarterly Journal of Agriculture"; and he published in the "Boston Medical and Surgical Journal" an article on the existence of nitrogen in plants and its origin in animals. He also contributed to journals in Edinburgh; and to the "Comptes Rendus," of the French Academy, "Observations sur quelques mines des États-Unis et sur le grès rouge de Lac Supérieur"; "Courans Marines"; "Nouveau gisement de Trilobites"; "Sur les gisements d'or dans le Géorgie"; "Sur le Bornite de Dahlonega et sur les diamants de l'État de Géorgie"; and other papers. His more elaborate works are the three reports on the "Geology of Maine," published in 1837, 1838, and 1839; reports on the "Public Lands of Maine and Massachusetts" (1837 and 1838); the "Report on the Geology of Rhode Island" (1840); "Reports of the Geology of New Hampshire" (1841, 1842, 1844); "Report on the Mineral Lands of the United States in Michigan" (1849, with maps). He also published the results of chemical researches on the cotton-plant, the tobacco-plant, on Indian-corn, and on thirty-eight varieties of American grapes, which were embodied in the Patent-Office reports, and a "Manual of Etherization, with a History of its Discovery" (1863).

Dr. Jackson died on the 29th of August, 1880, after having suffered for many years from an affection of the mind.

EDITOR'S TABLE.

THE SCIENCE OF BIBLICAL CRITICISM.

A CHANGE is gradually coming over the meaning of the word *science*, or, rather, there is a growing appreciation of its true meaning, which is of great significance. In the newspaper column of "Science" we have a list of results of late experiments of all kinds. In looking over many scientific periodicals it would be inferred that the term is restricted to physical science. From the text-books we should conclude that science consists of the facts and principles that have been established and collected in different groups under this name. But it now begins to be understood that science properly means a method by which all these results are produced. It is a method of thought, a method of investigation, having for its simple object the establishment of the truths of nature. This method has grown up gradually in modern times to greater and greater perfection, and has widened in scope, until now it includes many subjects with which it was at first supposed to have no relation.

There has of course been great resistance to this tendency. For, while people admit that truth is valuable and precious, they generally think that they are also in full possession of it, and are, therefore, in little need of methods to arrive at it. Their beliefs are truth, and therefore not to be disturbed. Science doubts, with a view to reinvestigation, and is hence unwelcome. Especially where men band together in parties and sects and declare their opinions, there arises at once a spirit of hostility to any thorough inquiry which might unsettle the views to which they are committed. Meantime, in spite of this resistance, the spirit of investigation has gained strength and spread rapidly in all directions of research.

The latest and most impressive proof of the progress of the scientific spirit is seen in the recent treatment of the Christian Scriptures. Biblical criticism has long been affected by the scientific method, and is now to be controlled by it. How far the critical spirit is already advanced and diffused, so that the Bible is regarded as a book with a human and an imperfect side, and containing errors that can be removed with better knowledge, is shown by the fact that the English translation of two hundred and fifty years' standing has been lately attacked by a body of able and learned revisers, who, after eleven years of labor, have just given us a corrected edition of the New Testament. This is a great step in the direction of rationalism. It concedes that the Scriptures must be subjected to the tests of reason, and this concession is due entirely to the modern scientific movement, which demands higher standards of proof, and more inexorable questioning as to what is true.

The revisers of the New Testament have fairly and formally entered the critical wedge, but the driving it home is to be no holiday affair. Professor Robertson Smith, one of the most learned, able, and candid of Biblical critics, having undertaken to treat the history of some parts of the Old Testament in a great encyclopædia, was met by his church and silenced in his professorship in the Aberdeen University. But the world gains by this act of intolerance. Professor Smith left the college halls and went out to give a course of popular lectures upon the

critical history of the Bible, which were attended by crowds of eager listeners. The lectures are collected in a volume that at once becomes a text-book of modern Biblical criticism. The true scientific ground is here openly and broadly taken, and it is generally admitted that Professor Robertson Smith's book represents authoritatively the scope and objects and method of the critical school which has been growing during the last half-century. It has thus at length become the benign office of Science to bring its methods to the responsible task of throwing a better light on the origin, history, and true character of the Christian oracles than has been derived from uncritical tradition. Nor does the critical attitude taken by Professor Smith at all compromise his Christian position. He is no skeptic, trying to undermine the Scriptures. He holds to their essential truth, but recognizes that on earth and in time, and among ignorant, selfish, and prejudiced men, truth is liable to be obscured. Professor Smith is in no sense an enemy of the Bible, as the following passage from his lectures sufficiently attests. He says:

> The Bible is a book of experimental religion, in which the converse of God with his people is depicted in all its stages, up to the full and abiding manifestation of saving love in the person of Jesus Christ. God has no message to the believing soul which the Bible does not set forth, and set forth not in bare formulas, but in living and experimental form, by giving the actual history of the need which the message supplies, and by showing how the holy men of old received the message, as a light to their own darkness, a comfort and a stay to their own souls.

But a majority of the Free Church of Scotland think that this is insufficient, and demand that he shall cease his critical studies. A large minority, however, see plainly that it is neither possible nor desirable to arrest the great inquiry that is now so far advanced and so securely established.

A CASE FOR THE ANTI-VIVISECTIONISTS.

Of all the forms of hostility to science indulged in by narrow-minded, prejudiced people, the anti-vivisection movement is unquestionably the most ridiculous. Vivisection is cutting the living; surgery is, therefore, human vivisection. The human person is liable to a thousand accidents and diseases, which can only be relieved by vivisection. The surgeon, with his cutting instruments of innumerable shapes, operates boldly upon the living system, inflicting pain that pain may be relieved, saving damaged organs, restoring health, and prolonging life. There is, indeed, no art practiced by man that is so valuable and important as that of human vivisection—and this, moreover, everybody knows.

But human vivisection, pursued for its beneficent purpose, is a difficult and dangerous practice. It requires the most accurate and thorough knowledge of the organization of the human body, and extensive experience in working upon it. In its early stages, when little was known of the living system, it was a dreadful barbarism, a manipulation of torture, and, in serious cases, more liable to injure than to benefit. The province of surgery has ever depended upon knowledge and experience, and it has become successful in proportion as knowledge has increased and the opportunities of practice have been enlarged. Modern surgery has advanced with the most rapid strides, and at every step has made humanity its debtor. And this, also, everybody knows.

Yet, from the beginning, men have combined to hinder the development of this art upon which so much of human welfare depends. For thousands of years the dissection of the dead human body—the only source of knowledge to the surgeon—was held a horrible thing by the multitude, was denounced as sacrilege by the Church, and was forbidden by the state.

In recent times it has been discovered that there is a unity of method and law running through all forms of organic life, such as was never suspected in former ages. This was a great step in the progress of science, and a great opening for the physician and surgeon, as the whole realm of inferior life was at once made tributary to the development of the physician's art—that is, the human vivisector, who had been hitherto greatly cramped and embarrassed by the difficulties and limited scope of his operations, could now carry on his inquiries more thoroughly and comprehensively by experiments upon the lower animals. It was a grand possibility, and, broadly considered, forms the most important step in the progress of medical and surgical science and art.

But, here again, ignorance and prejudice have, even in our day, combined to hinder the use and extension of knowledge vital to human benefit. As the human body was once forbidden to be dissected, so now it is forbidden to vivisect the lower animals. Anti-vivisection societies are formed, and anti-vivisection legislation is sought and has been obtained to defeat the work of the experimental physiologist. The anti-vivisectionists express great sympathy for the poor dumb animals, and assume to be their protectors. The sympathy is commendable, the function assumed a most proper one, and the field for the exercise of both boundless, so that these friends of the suffering animals can exhaust all their energies in protective work, without meddling with the physiologists.

But these stupid zealots deny that there is any use in vivisection, or that any good has ever come from it. They profess to know more about the matter than the physiologists and surgeons, and demand that Government shall stop the practice entirely. We have now a fresh illustration of what it it is that they would suppress. A malignant case of cancer of the stomach, such as have hitherto resisted all remedies, has been cured by a surgical operation which could never have been successfully performed but for long apprenticeship in vivisection. A large fibrous cancer had grown over the pyloric orifice of the stomach through which the food passes into the intestine, which was nearly closed, and must soon have killed the patient. The stomach was opened, the cancerous tumor removed, a new orifice prepared, the intestinal tube sewed fast to the stomach, and the patient recovered. The operation was performed by Professor Theodor Billroth, of Vienna, and his account of it was translated by the United States Minister to Austria, Hon. John A. Kasson, and sent to the "New York Tribune," from which we copy it. Professor Billroth says:

The removal of the frequently occurring carcinoma of the stomach, against which all internal remedies have been applied in vain, by the aid of surgery, has long been the subject of debate. Seventy years ago, a young physician, Karl Theodor Merrem, published a pamphlet in which he demonstrated, by experiments made upon three dogs, two of which survived the operation, that it was possible to cut out the pylorus and to join the duodenum with the stomach. He went even so far as to propose this operation in cases of human beings suffering with incurable carcinoma of the pylorus. In those days the conviction that the processes of life, their interruption and their equalization, were essentially the same in the human body and that of animals, had not obtained sufficiently, nor had the operative technique advanced far enough to cause the significance of these experiments to be fully appreciated and to render the application of the physiological result upon the human body possible. The best surgeons of France, England, and Germany have in the course of this century discussed the best methods of joining wounds of the stomach and the intestines. Since the discovery by Lembert of the only true principle upon which this operation can be carried out successfully, satisfactory results became of more frequent occurrence. But the excision of diseased parts of the intestines was not attempted until about ten years ago. In 1871

I demonstrated the possibility of cutting out sections of the œsophagus in large dogs, and that the wound healed, leaving the œsophagus slightly contracted but easily to be dilated. Czerny was the first to carry out this operation successfully upon a human being. His experiments to extirpate the larynx led to my successfully removing a human larynx obstructed by a cancerous growth. In 1877 I succeeded in performing the operation of gasteroraphy, which proved that no anxiety need be entertained as to the gastric juices of the stomach interfering with the scar-tissue so as to bring about its solution.

I have stated this for the benefit of those who are of the opinion that my operation is a reckless experiment on a human life. Such an opinion can not be entertained for one moment. The operation of cutting out parts of the human stomach has, like any other new operation, been prepared anatomic-physiologically and technically by myself and my assistants. Every surgeon, having any experience in experiments on animals, and similar operations upon the human body, arrives at the conclusion that this operation must and will succeed. Pean, the Paris surgeon, was of the same opinion. He attempted the removal of a cancerous pylorus, about six centimetres in diameter, in the case of a patient very much reduced by suffering, and who died four days after the operation. His method of operating, and especially his choice of catgut as sewing material, did not seem to me a good one. He has not attempted to repeat the operation, so far as I know, and no other surgeon has ventured to undertake this by no means easy task.

CUTTING A CANCER FROM THE STOMACH.

The few cases which came under my notice in the course of the past year did not seem to me to be proper ones for a first operation of this kind. It was only recently that the case of a woman was presented to me where the diagnosis of a cancerous pylorus was certain. After a few days of observation, the patient assenting, I made up my mind to undertake the operation. The woman, about forty-three years of age, and mother of eight children, was taken sick—very suddenly, it would seem—in October, 1880, with vomiting. The symptoms of cancer of the stomach with stenosis of the pylorus soon showed themselves. The only thing she was able to retain for any length of time was sour milk. The preparations for the operation consisted in accustoming the patient to peptonized injections, and the cleansing of the stomach by the well-known method of injection and pumping. The room, specially prepared for the occasion, was heated to 24° Réaumur, and the narcotic administered by one of my assistants, every one of whom seemed to be conscious of the importance of the undertaking. No interruption and not a minute of unnecessary delay occurred. The movable tumor, lying a little to the right, seemed to be of the size of an ordinary apple. A diagonal incision about eight centimetres long was made over the tumor, which proved to be a knotty and infiltrated cancer of the pylorus, occupying more than a third of the lower portion of the stomach. Separation of the adhesion to the omentum and the transverse colon followed; then the division of the large and small omentum. Every vessel was tied before being cut, the loss of blood being very small. The tumor was turned out over the abdominal walls, and a cut was then made through the stomach, one centimetre beyond the infiltrated part, at first only backward, then in the same manner through the duodenum. The attempt to put together the edges of the cut parts showed the possibility of joining them. Six stitches were taken through the edges, but the threads were not yet tied, and only used to retain the edges in position. A further cutting through the stomach was then made diagonally from the upper and inner to the lower and outer side, but always at a distance of one centimetre from the infiltrated portion of the coating of the stomach. The next thing done was to join the diagonal cut upward, until the opening was small enough to fit the duodenum to it. A complete separation of the tumor from the duodenum was effected next by an incision one centimetre on the other side of the infiltrated portion, and parallel to the cut through the stomach. Then the duodenum was introduced into the opening left in the stomach. About fifty stitches were taken with Czerny's carbolized silk. The whole was cleansed with a two per cent. carbolized solution. The stitches were then examined, and a few more added where there seemed to be weak spots. The whole was replaced in the abdominal cavity, the outer wound closed, and the bandages applied.

The operation lasted about one hour and a half. No weakness, no vomiting, and no pain seemed to be apparent after the operation. The patient was given ice only in the first twenty-four hours, then peptonized injections with wine; on the following day, at first every hour only, then every half-hour, a tablespoonful of sour milk. The woman slept the greater part of the night, with the aid of a small injection of morphine. The only food

taken for some days after the operation consisted of sour milk, one litre a day, as an attempt to nourish the patient with broth did not seem acceptable to her. The peptonized injections were dispensed with, as they produced flatulence and colic. Injections of wine three times daily were therefore substituted. The patient, upon her own request, was a few days later removed to the general ward, and she has since been discharged from the hospital, cured. The excised part measures at the greater curvature (*horribile dictu!*) fourteen centimetres, and it is with difficulty only that I am enabled to pass a goose-quill through the pylorus. The shape of the stomach is changed little by the operation. It is only a little smaller than formerly.

LITERARY NOTICES.

General Physiology of Muscles and Nerves. By Dr. J. Rosenthal, Professor of Physiology in the University of Erlangen. ("International Scientific Series," No. XXXII.) New York: D. Appleton & Co. 1881. Pp. 324. Price, $1.50.

Professor Rosenthal has well conformed to the theory of the "International Scientific Series" in the preparation of this work. It was designed to consist of monographs on special subjects, and not of complete scientific treatises. In this way particular subjects may be more fully expounded than they are in the text-books, while yet the form of publication is popular and convenient. If any one, for example, looks in the manuals of physiology for a statement of the relations of muscles and nerves, he will find that the information, if not scanty, is still most incomplete. Yet such are the interest and importance of the subject, that many would like to consult a more adequate presentation. Professor Rosenthal's volume will meet their requirements. It goes over the whole ground of the recent researches into muscular and nervous action, and is, moreover, the first attempt to deal with it in a popular and methodical way.

But few men could have been found as well prepared for the execution of his task as Professor Rosenthal. The problem of muscles and nerves has occupied his life. He worked for many years in connection with Professor Émile Du Bois-Reymond, the celebrated Berlin physiologist, to whom the present volume is dedicated. Broadly cultivated in the physiological field, and long disciplined in the experimental research of nervo-muscular relations, he has been enabled to give weight and authority to his exposition of the subject.

On general and obvious grounds, no subject is more important than this, and we can think of none that should more deeply interest all classes of readers. Man is a being endowed with great capacities of accomplishment by virtue of the agency of muscles and nerves. They are the means of his pleasures and the sources of his pains. One would think that he might be concerned to understand something about them; and, if he has any sense of the relative values of different kinds of knowledge, that he would place the understanding of his own mechanism first, and desire a thorough acquaintance with all that is positively known concerning the conditions of muscular and nervous exercise. The topic, besides, is one of profound intellectual interest. Nothing is more wonderful than the working of that higher organic mechanism by which power in the living being is exerted and controlled. There is nothing so subtile, so curious, so marvelous, as that incessant interaction of the muscular and nervous systems which is involved in all the familiar activities and operations of the human body. The strange thing is how it has been so finely and fully elucidated. Many things, of course, remain still mysterious and unsettled, but we have a large body of well-established facts and principles that have been most difficult of determination, and which forms one of the great monuments of skillful, persevering, and successful scientific labor. Physics and chemistry are generally spoken of as the experimental sciences, but physiology is also now in the highest sense an experimental science, while, for delicacy and difficulty of operation and consummate contrivances for dealing with obscure and complex phenomena, the physiological laboratory has precedence of all the workshops of experiment. Professor Rosenthal's book is filled with elegant illustrations of physiological instruments and apparatus, and there are many exquisite

diagrams to show the interactions of the nervous and muscular parts, as it is now proved that they take place.

We have here no space for the details of the book, but may refer to one of the most delicate and interesting of the machines employed, which is a device for the electric measurement of the muscle-pulsation. By its use the infinitesimal periods of time consumed in these pulsations are magnified and represented side by side in a wavy line, so that their durations can be compared and measured by a standard. The continued strain of a muscle is shown to be a chain of these tiny pulsations which decline steadily in strength as each pulsation exhausts a certain amount of material corresponding to the carbon removed from its place under the steam-boiler by combustion. The modern view that the power generated by muscle is due to the hydrocarbonaceous matter oxidized, instead of the nitrogeneous element of muscular structure, is clearly brought out.

It has long been a question in what way the nerves are mechanically or structurally related to the muscles, or what is the nature of the ultimate connection. Of course this was a microscopical problem upon which further light was constantly thrown as the instruments reached higher powers, and observers became more skilled in their use, and more experienced in guarding against errors. As was natural, different views were entertained by different able observers, and, as was equally natural, sharp controversies followed. How the case stands at present may be gathered from the following statement from Chapter XV: "If we trace the course of the nerve within the muscle, we find that the separate fibers, which enter the muscle in a connected bundle, separate, run among the muscle-fibers, and spread throughout the muscle. It then appears that the single nerve-fibers divide, and this explains the fact that each muscle-fiber is eventually provided with a nerve-fiber—long nerve-fibers even with two—although the number of nerve-fibers which enter the muscle is generally much less than the number of the muscle-fibers which compose the muscle. Till the nerve approaches the muscle-fiber, it retains its three characteristic marks—the neurilemma, medullary sheath, and axis-cylinder. When near the muscle-fiber the nerve suddenly becomes thinner, loses the medullary sheath, then again thickens, the neurilemma coalesces with the sarcolemma of the muscle-fiber, and the axis-cylinder passes directly into a structure which lies within the sarcolemma pouch, in immediate contact with the actual muscle-substance, and is called the *terminal nerve-plate*." There are some differences here in different classes of animals, but "the essential fact is the same in all cases: *the nerve passes into direct contact with the muscle-substance.* All observers are now agreed on this point. Uncertainty prevails only as to the further nature of the terminal plate."

The Old Testament in the Jewish Church: Twelve Lectures on Biblical Criticism. By W. Robertson Smith, M. A. New York: D. Appleton & Co. 1881.

Probably no subject which interests so many people and interests them so deeply is so little studied or understood as the history of the Bible. In these three kingdoms there are every Sunday between fifty and sixty thousand clergymen of various religious bodies discoursing upon it, a very much larger number of persons teaching it in Sunday-schools and day-schools, an overwhelming majority of the population reading it, more or less, and looking to it as the guide of faith and practice. Yet not one man in a thousand, even in the educated classes, knows anything about the respective dates of the different books of the Bible, the mode in which they were preserved and received into the canon of Scripture, or the views entertained by scholars as to their authorship. This ignorance is deepest and most widespread as regards the Old Testament. Wonderful progress has been made during the last fifty years in the criticism of the numerous writings which make it up. It is not too much to say that we have gained more knowledge on the subject within that period than all the labors of all Biblical scholars succeeded in amassing during the two thousand years that preceded. Yet the bulk of the English cultivated public, which learned at college at least all that is known about the Servian Constitution and the Twelve Tables, which has a fair idea

of the issues of the great Homeric controversy, has no idea of the fresh light that has been thrown on the books which are read under the name of Moses, or the character and historical position of such men as Samuel, David, or Isaiah. Oriental scholars, a very small class in England, have been so much occupied in study as to have scarcely cared to give the results of recent inquiry to the general public. Lately some valuable translations of German treatises have begun to appear, but these have been too elaborate and bulky to attract ordinary readers. The appetite has continued to languish for want of the proper food.

It need now languish no longer. Professor Robertson Smith's book is exactly what was wanted at once to inform and to stimulate. Written by one of the first Semitic scholars of our time, it is completely abreast of the most recent investigations, and pervaded by a thoroughly scholar-like spirit. His easy mastery of the subject and his sense of which are the really difficult points and which the settled ones are apparent on every page. What is more surprising is the skill wherewith these resources are used. Although scientific in the sense of being thorough, exact, and business-like, the book is also popular—that is to say, it is perfectly intelligible to every person of fair general education who has read the Bible. For clearness of statement, for cogency of argument, for breadth of view, for impartiality of tone, for the judgment with which details are subordinated to the most interesting and instructive principles and facts, it is a model of how a great and difficult subject should be presented to the world. It is so condensed as to need close attention. But those who have any taste for these studies will not find it hard to give that close attention, for it carries one on like a romance from beginning to end, and we can well believe, what was stated in the newspapers some weeks ago, that the lectures, of which it is a summarized reprint, were listened to by immense audiences in Scotland with the keenest interest.

The book opens with a sketch of the criticism of the Old Testament in the Christian Church from the days of the earliest Fathers. It is shown how their entire want of Hebrew scholarship contributed, with their theories as to the nature and value of Scripture, to lead them away from a critical interpretation of the text; how even Jerome was obliged, when making his famous translation, to lean upon Jewish rabbis; how it was only among the Jews that the knowledge of the old language was preserved down till the Reformation, when such revivers of learning as Reuchlin drew their knowledge from Jewish sources; how thus the traditional interpretations and notions which were current among the Jews continued to influence Protestant scholars in their translations, and have colored our own authorized version. Then the author goes on to show how the Jewish traditional interpretation was itself formed. Old Hebrew became a dead language in or before the fourth century B. C., so that the Jews of our Lord's time, speaking Aramaic, needed special school-training to understand the Law, the Psalms, and the Prophets. As there were no grammars nor dictionaries, the knowledge of the old tongue was given orally, and a traditional mass of learning grew up, consisting of the interpretation of the sacred writings, with explanations and commentaries, partly legal (the so-called Halacha), partly moral or hortatory (the Haggada). The Law having now become the center of the whole life of the nation, as well civil as religious, and the guide of all its habits and usages, the function of those who interpreted and expounded and applied it became an extremely important one, and they rose, in the period between the return from Babylon and the birth of Christ, into a class of great power and influence. They are those whom we find mentioned in the New Testament as the Scribes, mostly belonging to and in fact heading the party called Pharisees. Their interest in the Law was primarily practical, and in their work of extending, supplementing, harmonizing, refining upon its rules they created a large body of customary law side by side with it, and were thus led to originate many forced and unreasonable interpretations, which have come down to us in the Talmud, and long continued to pervert the true meaning of the old writings. Though philology or grammatical exegesis was not in their way, nor indeed within their com-

petence, they were of course zealous for the preservation of a correct and uniform text, and it was apparently by them that the text which we now have was fixed. The date of this fixing becomes important, and may be proved by incidental evidence. Down to the apostolic age there seem to have been manuscripts of the various books of the Old Testament in circulation which varied considerably from one another; this appears by the divergences from our received text both of the Septuagint Greek translation made in the third century B. C., and of the Samaritan Pentateuch dating from the fifth century B. C., as well as by other evidence. But all our present MSS., none of which is older than the ninth century A. D., present what is practically one and the same text—showing that they must have been made from one archetypal MS. This text is the same text as Jerome used in making his Latin version in the fifth century A. D.; and it may be traced back with some certainty to the second century A. D. There is, therefore, good reason to believe that in the first Christian century one MS.—probably one of the three which we are told were then preserved in the Temple—was taken as authoritative, and all official copies ordered to be thenceforth made from it, every other MS., showing a different text, being discredited or even suppressed. From that time the text was guarded with the most scrupulous care, copies being made by a guild named the Massorets (possessors of tradition), who did not venture to change even an accidental peculiarity of writing. But, as many centuries had elapsed between the original writing of the books and the determination of this received text in the post-apostolic age, many variations had of course grown up. By far the most ample evidence of these variations is that supplied by the Septuagint; and one of the most interesting parts of Professor Smith's book consists in his account of the relation between the present Hebrew text and this old Greek translation, which carries us back to forms of the text that afterward perished. In common with the bulk of recent scholars, he sets a high value on many of the Septuagint readings, conceiving that they often give passages in a simpler and earlier form than that of the established Hebrew, which has been injured by the amplifications of editors, or, in some few cases, altered by copyists who did not fully understand the old language. These variations are more numerous and important in the Prophets than in the Law, because the latter held so important a place in the services of public worship, where it was read through once in three years, that the copying of it was performed more accurately and a uniform text better preserved. The author then goes on to show how little reliance can be placed on some of the titles prefixed to the canonical books, and how many traces we find of the action of a succession of editors or *rédacteurs* in getting the books into their present shape. Explanations were added; one document was joined on to another; in some cases it would seem that a book was written by taking an old series of annals or official records and filling into it anecdotes and descriptions from some other source. Next the formation of the Old Testament canon is discussed; and it is shown how, as in the case of the New Testament, different views as to the canonicity of particular books were from time to time prevalent among the Jews down till the second century A. D. The tales which ascribe the settlement of a canon to Ezra or to Nehemiah are shown to rest on no foundation. The inclusion of some of the Apocryphal books in the Septuagint shows that among the Alexandrian Jews these books enjoyed a certain authority, and yet they are not quoted—by Philo, for instance—as if they stood on the same level with the Prophets; for there was a feeling, a true feeling, that the prophetic voices had come to an end a few generations after the return from Babylon, or as Josephus too precisely puts it, in the time of Artaxerxes I. These books are all comparatively late, and to modern criticism stand on quite a different footing from the Prophets, whose authority seems to have become early established. But grave doubts were long entertained as to some of what we now consider canonical books. Daniel and Esther were disputed in the apostolic age, Ecclesiastes and the Song of Solomon not finally admitted till the time of Rabbi Akiba, who lived under Hadrian.

The second half of Professor Robertson Smith's book is devoted to an inquiry into

the relative date of the more important of the Old Testament books, and particularly of the Pentateuch. He examines the view, which has been traditional among Jews and Christians for two thousand years or so, that the books containing the Law of Moses are the oldest part of all the sacred writings, and belong to the time of Moses himself; pointing out that on this hypothesis we may reasonably expect to find many references to it in the historical and prophetic books, which would show that its ordinances were well known and were obeyed at least by the loyal worshipers of Jehovah, even if neglected by a large part of the nation during its frequent lapses into idolatrous worship. And he remarks with great truth that, considering not only the importance of ritual in early times, but the great prominence given to ceremonial in the Levitical system, the way in which "the feasts, the sacrificial ritual, the ordinances of ceremonial purity are always in the foreground, as the necessary forms in which alone the inner side of religion, love to God and man, can find acceptable expression," the observance of these forms and rites must have been a matter of the highest consequence, a matter in which the devotion of good kings and priests would appear, and on which the prophets would frequently insist in their exhortations to the people. The Law purporting to be, as we read it, a complete revelation of God's will for Israel's life, a rule of absolute validity, the keeping of which is the whole of Israel's religion, "the religious history of Israel can be nothing else than the history of Israel's obedience or disobedience to the law." Moreover, the position "that the whole legal system was revealed to Israel at the very beginning of its national existence, strictly limits our conception of the function and significance of subsequent revelation. The prophets had no power to abrogate any part of the law, to dispense with Mosaic ordinances, or institute new means of grace, other methods of approach to God in lieu of the hierarchical sacraments." The theory, the usual orthodox theory of modern times, that the prophets were "exponents of the spiritual elements of the law, who showed the people that its precepts were not mere forms, but veiled declarations of the spiritual truths of a future dispensation which was the true substance of the shadows of the old ritual, implies that the prophets were constantly intent on enforcing the observance of the ceremonial as well as the moral precepts of the Pentateuch. Neglect of the ritual law was all the more culpable when the spiritual meaning of its precepts was made plain."

To give this brief summary of Professor Robertson Smith's conclusions conveys a very imperfect idea of the admirable skill with which he applies his critical method. It sets familiar facts and expressions in a perfectly new light, illumining for us the whole religious and political history of Israel, and making that history more intelligible, more self-consistent, more instructive, than it had ever appeared upon the traditional view. — *Abridged from the Pall Mall Gazette.*

Trance and Trancoidal States in the Lower Animals. By George M. Beard, A. M., M. D. New York. Pp. 17.

Trance is defined by Dr. Beard as "a concentration of nervous activity in some one direction, with corresponding suspension of nervous activity in other directions." It can be induced in all animals that have the rudiments of a nervous system, and is essentially the same in all, the differences that may be observed being in degree rather than in kind. The methods of inducing it are infinite, and no one of those that are best known can be said to have any special or preëminent virtue over any other, except of convenience and degree. Induced trance, by whatever way it is brought about, trance resulting from functional derangements, and spontaneous trance, are all parts of and obedient to the same law, and should be studied under that view. Hence special terms, like hypnotism, Braidism, somnambulism, catalepsy, etc., are misleading, and ought not to be used. Among the examples of trance in animals, Dr. Beard cites the various methods of subduing them by fear, lion-taming, the horse-taming operations of Rarey and Home, affecting them with music, all the phenomena that pass under the name of fascination, and stupefaction in the presence of fire.

Journal of the Academy of Natural Sciences of Philadelphia. Vol. VIII. Second Series. Part IV. Philadelphia: Printed for the Academy. Pp. 120, with Nine Plates.

This part of the Academy's "Journal" contains four papers, of which the first two, embodying descriptions of the Miocene and Pleiocene fossils of the Caribbean area and Costa Rica, were written by the late William M. Gabb while in San Domingo, during the winter of 1877-'78, and have been published since his death. The third paper is on "The Terrestrial Mollusca inhabiting the Cook's or Harvey Islands," by Andrew Garrett. The next paper, on "The Placenta and Generative Apparatus of the Elephant," by Henry C. Chapman, M. D., is based on observations of a female elephant attached to a menagerie, that gave birth to a young one in Philadelphia in 1880, and establishes the interesting fact that the period of gestation of the elephant is from six hundred and thirty to six hundred and fifty-six days. The other papers are by Joseph Leidy, M. D., and are on "The Parasites of the Termites," and on the *Bathygnatus borealis*, a fossil saurian from Prince Edward Island.

Second Report of the United States Entomological Commission for the Years 1878 and 1879, relating to the Rocky Mountain Locust and the Western Cricket. With Maps and Illustrations. Washington: Government Printing-Office. Pp. 322; and Appendices, pp. 80.

The present report embodies the conclusions that have been reached after careful examinations of the breeding-ground of the insects, of the regions in which they are permanently propagated, and of the "temporary region" where they may breed for a few years and then die out, with other knowledge that has been gained concerning their habits, and the best means of contending against them. The Commission claims that its prediction, that the series of invasions by the locust of the cultivated regions that began in 1874 would close in 1877, has been completely confirmed, and that its theory that the pest could not remain permanently in this region has been conclusively proved; consequently, the insect no longer excites the terror which its first appearances evoked. The locust is bred in the prairie tracts of the rainless district, in the loose, warm, gravelly soil, in the comparatively open spots, rather than in the thick grass, in different parts of a "permanent region," the area of which is not less than five hundred thousand square miles. The best single means of exterminating the broods would be to burn the grass while they are in the larva state; but this can not be relied on alone, because of the great extent of uninhabited country to which it would have to be applied, and because it can not be made thorough, since the burning would be lightest in the spots where the insects are thickest. The object must be promoted by other means, of which the first is to induce the settlement of the breeding district by farmers, who will fight the locusts in their homes; next, by the encouragement of irrigation, to bring unfriendly water to bear upon them, and of the planting of forests, in which they do not flourish; and by instituting a system of Signal-Service warnings of the progress of their migrations. The discussion of these points forms one of the most important chapters of the report; and this chapter, with the eight maps showing the vegetation of the regions the insects infest, has been also published separately. In addition to these topics, information is given concerning the migrations and ravages of locusts in other countries, their natural history and structure, and their natural enemies.

Coöperation as a Business. By Charles Barnard. New York: G. P. Putnam's Sons. Pp. 234. Price, $1.

Mr. Barnard devotes a chapter to the description of each of the principal forms in which coöperation has been practiced with success. In the first chapter the workings of the Philadelphia building associations are explained in full; accounts are given of the English systems nearest like theirs; the English and American systems are compared; and coöperative banks are explained. The second chapter is devoted to the coöperative stores that have been established in Great Britain for the benefit of consumers; the third to those which are conducted in the interest of producers, of which the establishment of the Paisley shawl-weavers is taken as the type. In the suc-

ceeding chapters are described the civil-service and similar stores, the coöperative insurance societies, the provident dispensaries, and the people's banks. The scope of the work is not, however, limited to the consideration of schemes of coöperation that have succeeded. Attention is also given to those that have failed, particularly in the United States, and the attempt has been made to examine and analyze the causes that have conduced to failure.

Contributions to the Anatomy of the Milk-Weed Butterfly, Danais Archippus (*Fabr.*). By Edward Burgess, Secretary of the Boston Society of Natural History. Boston: Published by the Society. Pp. 16, with Two Plates.

This monograph is intended to serve as a guide to the general study of the structure of the *Lepidoptera*. The particular species is chosen as a type of the order well adapted to the purpose, on account of its large size, common occurrence, and wide distribution, and partly because the anatomy of no species of *Danaidæ* has yet been studied.

Locke's Conduct of the Understanding. Edited, with Introduction, Notes, etc., by Thomas Fowler, M. A. Oxford: The Clarendon Press. Pp. 136. Price, 50 cents.

Although this fragment is not finished, but was written and left only as a rough draught of a chapter which the author intended to complete and add to its essay, it has been regarded, even in its crude shape, as one of the most valuable aids to self-culture. Professor Fowler has endeavored to make it more generally useful by means of added notes and suggestions, without changing the text.

Middletown Scientific Association. Occasional Papers. No. 1. Annual Address of the President, Rev. Frederick Gardner, D. D., January 18, 1881. Middletown, Connecticut. Pp. 19.

The address marks the completion of the tenth year of the Association, the meetings of which have been kept up all the time with reasonable regularity. The President discusses the special subject of "The Universality of the Laws of Heredity and Variability."

Railroads and Telegraphs: Who shall control Them? By F. H. Giddings. Springfield, Massachusetts: "The Manufacturer and Industrial Gazette." Pp. 12.

The author recognizes the wickedness of monopolies and the abuses they engender, but holds that the remedy is not to be found in State possession or control of railroads and telegraphs. Any close regulation or supervision by the State would aggravate the evils and increase the number and power of rings. The people who use the lines should take the control into their own hands by becoming stockholders and attending to the management of them.

The Diet-Cure; the Relations of Food and Drink to Health, Disease, and Cure. By T. L. Nichols, M. D. New York: M. L. Holbrook & Co. Pp. 83. Price, 50 cents.

This book teaches that pure food makes pure blood, and pure blood builds up a healthy body. The author believes that it is needed, notwithstanding all that has been written on the subject, because "there are still people who eat and drink more than is good for them, as well as what is bad for them."

Modern Architectural Details: For Dwellings and Cottages in Modern Styles. New York: Bicknell & Comstock. To be completed in Ten Parts, each containing Eight Plates. Price, $1 for each part.

The purpose of this work is to present new and original designs of dwellings at moderate cost, in the Queen Anne, Eastlake, Elizabethan, and other modernized styles, exterior and interior details of houses, stores, offices, etc., and designs of low-priced-cottages. The drawings are furnished by a considerable number of contributors, so that variety is assured. The sixth number contains perspectives of two dwellings, with the details carefully wrought out.

The Magazine of Art, April, 1881. London, Paris, and New York: Cassell, Petter, Galpin & Co. Pp. 48. Price, 35 cents.

This number contains, besides special papers, articles on "Symbolism in Art," "Architectural Sculpture," and the "Ideal in Ancient Painting."

How to tell the Parts of Speech; an Introduction to English Grammar. By the Rev. Edwin A. Abbott, D. D. American edition, revised and enlarged, by John G. L. McElroy, A. M. Boston: Roberts Brothers. Pp. 143. Price, 75 cents.

Dr. Abbott is also the author of other works on the construction of the English language, which, with this, have the common characteristics that, in them, the artificial rubbish that overloads nearly all English grammars is rejected, and the endeavor is made to place the study of the language on a basis of common-sense. They are prepared under the conviction that it is the business of a teacher to teach the boy not how to speak, but how to understand, English, and how to see the reasons for the anomalies in the language; that the pupil should first learn to perceive the function of the word, and thence deduce its grammatical quality, rather than to give first the grammatical definition, and afterward seek the reason for it.

A Fourth State of Matter. By Alexander E. Outerbridge, Jr. Philadelphia. Pp. 11.

This is the substance of a lecture which was delivered before the Franklin Institute, February 17th last, when some of the experiments of Professor Crookes were repeated and his theory was explained with familiar illustrations and a reference to the "vortex atom theory" of Sir William Thomson.

Report of the Director of the Detroit Observatory of the University of Michigan to the Board of Regents. For the Period beginning October 1, 1879, and ending January 1, 1881. Ann Arbor, Michigan: Published by the Regents. Pp. 20.

In the astronomical department of the observatory two comets were discovered, one of which was new; the other had been seen the evening before at Strasburg. The meteorological observations were directed to the study of the climate of Ann Arbor, the daily fluctuations of the meteorological elements, and the character of local storms. As collated and summarized in the report, and compared with the general observations of the Signal Service, they furnish facts of much value.

Report of the Superintendent of the United States Coast and Geodetic Survey. Appendix No. 10, Meteorological Researches. By William Ferrel. Part II. On Cyclones, Tornadoes, and Water-Spouts. Washington: Government Printing-Office. Pp. 95, with Six Plates.

The theory of cyclones is wrought out in the first chapter with great care and elaboration. In the second chapter, the practical applications of the theory, as its operation is modified by the encounter with actualities, are discussed, and the theoretic results are compared with those of observation. The third chapter is devoted to the phenomena of tornadoes, hail-storms, and water-spouts.

Our Trees in Winter. By John Robinson. From the Bulletin of the Essex Institute. Vol. XII. Pp. 16.

This is the substance of a paper which was read at the first winter field meeting of the Essex Institute, at Chebacco Pond, held in January last. It discusses the faculty which many trees possess of adapting themselves to different climates; the manner in which trees escape injury from freezing through the withdrawal of water from their tissues in winter; and the opportunities which winter affords for the study of trees, which are better for many purposes than those given by summer.

Report of the Cruise of the United States Revenue Steamer Corwin in the Arctic Ocean. By Captain C. L. Hooper, U. S. R. M. Washington: Government Printing-Office. Pp. 73, with Five Charts.

The Corwin left Oonalaska June 8, 1880, and proceeded by way of Nunivak Island, St. Lawrence Island, Kotzebue Sound, the "ice-deposits" of Elephant Point, and the coal-veins of Cape Lisburn, to Point Barrow, and thence to Herald Island and within twenty-five miles of Cape Wrangel, whence it returned. During the cruise, observations were taken on the lands and the people, the illicit trade of the coast was looked after, and the Jeannette was inquired for. The report contains fresh and valuable anthropological notes, observations on natural history, and "the ice and its habits," and views of prominent points.

Industrial Conciliation and Arbitration in New York, Ohio, and Pennsylvania. By Joseph D. Weeks, A. M. From the Twelfth Annual Report of the Massachusetts Bureau of Statistics of Labor. With Comments by Carroll D. Wright, Chief. Boston. Pp. 75.

Mr. Weeks has furnished in this paper a large amount of information from the experience of business establishments in his own and other States. Conciliation is the arrival at a mutual understanding, in case of difficulties between employers and employed, either through their own discussions or the intervention of friendly parties, and is voluntary. It was first brought into effect in the iron-works at Pittsburg, in 1866, and has been continued, with only such interruptions as were provided for in the agreements and were consistent with their terms, till the present time. Thence it has been extended to establishments in West Virginia and Ohio. Arbitration is reference of the dispute to an umpire, whose decision is intended to be binding. It has been tried in the anthracite, Pittsburg, and Shenango coal-regions in Pennsylvania, and in the coal-mines of Ohio, and has always so far failed. One instance of its successful operation in this country is in a large cigar-manufactory in this city, where the relations between the proprietors and their workmen appear to be established on the most agreeable basis. The full history of all these efforts is given in the pamphlet.

Observations on Jupiter. Presented to the American Academy of Arts and Sciences, March 9, 1881. By L. Trouvelot. Pp. 22.

M. Trouvelot began in 1876 a series of observations on the planets, for the purpose of studying them at every point of their orbits. Five hundred and ninety-one observations were made on Jupiter during five years, and not quite as many drawings were taken. The planet showed signs of lively commotion in 1876, when a spot was recognized on a second observation only once. During the following years the planet was more quiet, the spots were more durable, and one, the "great red spot," was persistent for several months. The periods of rotation of the planet, as deduced from observations of the spots, exhibit variations which appear to be dependent upon their proper motion. The great spot gives a period of between 9h. 55m. 38·81s. and 9h. 55m. 43·96s. M. Trouvelot thinks this is as near to the actual period as we are ever likely to arrive.

Working Drawings, and how to use Them. By Lewis M. Haupt, Professor of Civil Engineering in the University of Pennsylvania. Philadelphia: Joseph M. Stoddard & Co. Pp. 55, with Nine Charts of Figures.

By the usual teaching of drawing, pupils learn to observe and copy from models, and to construct perspectives "by rule-of-thumb," but not, the author believes, except in the case of patterns for tapestry, carvings, and similar applications, to invent designs from which constructions can be made. For this purpose the designer should be able, in order that the object he conceives may be constructed from the drawing, to dissect it and so to project its several parts on the plane of the paper, that the artisan shall know just where to find them, and what they represent. The present work is designed as an introduction to this branch of the study.

Imaginary Quantities: Their Geometrical Interpretation. Translated from the French of M. R. Argand. By Professor A. S. Hardy. New York: D. Van Nostrand. Pp. 135. Price, 50 cents.

M. Argand was the first who undertook (in 1806) to suggest the true theory of the so-called imaginary quantities of mathematics. He was followed, twenty-five years afterward, by Gauss, and later by other authors who have given the subject a fuller development. The translation of his essay is followed in the present volume by notes on the geometrical interpretation of imaginary quantities by Professor Hardy.

The Endowment of Scientific Research. From the Annual Address of the President of the California Academy of Sciences, Professor George Davidson, A. M., Ph. D. Pp. 8.

This is a strong presentation of the proofs that science is economically profitable, and of the arguments in favor of its endowment with means to prosecute investigations.

ABSTRACT OF TRANSACTIONS OF THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON, D. C., with the Annual Address of the President, for the First Year, ending January, 1880, and for the Second Year, ending January 18, 1881. Prepared by J. W. POWELL. Washington. Pp. 150.

THE President's address reviews the work of the Society during two years, and describes generally the papers that were read, according to the particular department of anthropological science to which they severally relate. The papers for the most part concern American subjects, and are founded on original observations. The summaries contain much that endows the subject with interest and is adapted to stimulate continued investigations.

THOUGHTS ON AGRICULTURAL EDUCATION. By E. LEWIS STURTEVANT, M. D., South Framingham, Massachusetts. Pp. 19.

DR. STURTEVANT explains in an address the purpose and scheme of an agricultural college. In the discussion following the address, a minute of which is published with it, the teaching of agriculture in the common schools and the relative importance to farmers of instruction in advanced arithmetic and agricultural chemistry are considered.

THE NATURE OF VIBRATION IN EXTENDED MEDIA AND THE POLARIZATION OF SOUND. By S. W. ROBINSON, Professor of Physics and Mathematics, Ohio State University.

THIS is mainly an argument, based upon experiments made by the author in effecting the polarization of sound, to show that the phenomena of polarization of light, heretofore supposed to be due to transversal vibrations, can be explained on the basis of longitudinal vibrations alone. This done, no reason is left for assuming that the waves of light differ in character from other waves which are the result of longitudinal vibrations. The experiments and their results are described in detail.

HISTORY OF THE CHRISTIAN RELIGION TO THE YEAR 200. By CHARLES B. WAITE, A. M. Chicago: C. V. Waite & Co. Pp. 455. Price, $2.50.

THIS work is the result of years of laborious study, in which the author professes to have consulted all the writings of the first two centuries, and the works of the fathers of the Church, "in the interest of no church, creed, or dogma," but for his own satisfaction. In it he discusses the origin and history of all the gospels, those which are called apocryphal, forty in number, as well as those which have become canonical, and has compared three of the most famous of the apocryphal gospels in parallel passages with the canonical records. He adds sketches of nearly a hundred Christian writers of the first two centuries, with notices of their works, and a history of Christian doctrine for the same period, and declares his conclusions as to what is genuine.

A PRACTICAL TTEATISE ON NERVOUS EXHAUSTION (NEUROSTHENIA); ITS SYMPTOMS, NATURE, SEQUENCES, TREATMENT. By GEORGE M. BEARD, M. D. Second and revised edition. New York: William Wood & Co. 1880. Pp. 198. Price, $1.75.

NERVOUS exhaustion, according to Dr. Beard, is more common in this country than any other form of nervous disease, and, with other forms toward which it tends, constitutes a family of functional disorders that are of comparatively recent development, and that especially abound in the northern and eastern part of the United States. The author gives, in this volume, the result of the study and experience of his entire professional life on the subject. He describes the symptoms of the disease, showing their relations and interdependence, distinguishing them from the often closely resembling symptoms of other diseases, and discusses the complex developments and manifestations of the malady, its pathology, treatment, and hygiene. The consideration of the causes of the disorder is left for another volume.

PUBLICATIONS RECEIVED.

On Philadelphite. By Henry Carvill Lewis. Reprinted from the "Proceedings of the Academy of Natural Sciences," of Philadelphia. 1879. Pp. 16.

Extinct Cats of North America. 1880. Pp. 25. Some New Batrachia and Reptilia from the Permian Beds of Texas, etc. 1881. Pp. 45. The Systematic Arrangement of the Order Perissodactyla. 1881. Pp. 26. Second Contribution to the History of the Vertebrata of the Permian Formation of Texas. 1881. Figures. By Professor E. D. Cope.

The Bolometer. By Professor S. P. Langley.

Read before and published by the American Metrological Society. New York. 1881. Pp. 7. Illustrated.

Geological Survey of Alabama. By Eugene A. Smith, Ph. D. Montgomery, Alabama. 1881. Pp. 158, with Maps.

Politico-Social Functions. By Lester F. Ward. Reprint from "Penn Monthly." 1881. Pp. 16.

A Collector's Notes on the Breeding of a Few Western Birds. By J. Holterhoff. 1881. Pp. 12.

The Climate, Soils, Timber, etc., of Kentucky contrasted with those of the Northeast. By John R. Proctor. Frankfort, Kentucky. 1881. Pp. 29.

Notes on North American Microgasters. By C. V. Riley, Ph. D. From the "Transactions of the St. Louis Academy of Sciences." 1881. Pp. 20.

Ninth Annual Report of the Board of Directors of the Zoölogical Society of Philadelphia. 1881. Pp. 32.

Mya Arenaria in San Francisco Bay. By Robert E. C. Stearns. Reprint from "The American Naturalist." 1881. Pp. 5.

The Landa Alphabet. A Spanish Fabrication. 1880. Pp. 35. Mexican Paper, an Article of Tribute. Its Manufacture, Varieties, and Uses. 1881. Pp. 26. By Philipp J. J. Valentini, Ph. D. Worcester, Massachusetts.

Inductive Metrology. By W. J. McGee. Reprint from "The American Antiquarian." 1881. Pp. 8.

Nostrums in their Relation to the Public Health. By Albert B. Prescott, M. D., F. C. S. Reprint from "The Physician and Surgeon," Ann Arbor. Michigan. 1881. Pp. 12.

Principal Characters of American Jurassic Dinosaurs. By Professor O. C. Marsh. Part V, with Seven Plates. Reprint from the "American Journal of Science." 1881. Pp. 7.

Antiquities of New Mexico and Arizona. By W. J. Hoffman, M. D. Davenport Academy of Natural Sciences. 1881. Pp. 18. Four Plates.

Gill Nets in the Cod-Fishery, etc. By Captain J. W. Collins. Bulletin U. S. Fish Commissioner. 1881. Pp. 17. Twelve Plates.

The Total Solar Eclipse of July 29, 1878. Observations at Pike's Peak, Colorado. Report of Professor S. P. Langley. Pp. 14, with Plate.

Anthropology: an Introduction to the Study of Man and Civilization. By Edward B. Tylor, D. C. L., F. R. S. With Illustrations. New York: D. Appleton & Co. Pp. 448.

English Philosophers. David Hartley and James Mill. By G. S. Bower, M. A. New York: G. P. Putnam's Sons. Pp. 250. $1.25.

Osteology of Speotyto Cunicularia, Var. Hypogæa, and of Eremophila Alpestris. By E. W. Shufeldt, First-Lieutenant and Assistant Surgeon, U. S. Navy. Washington, D. C. Pp. 60, with Four Plates.

Literary Style, and other Essays. By William Mathews, LL. D., author of "Getting on in the World," etc. Chicago: S. C. Griggs & Co. Pp. 345. $1.50.

Text-Book of Experimental Organic Chemistry for Students. By H. Chapman Jones. New York: D. Van Nostrand. Pp. 115.

The Wilderness-Cure. By Marc Cook, author of "Camp Lou." New York: William Wood & Co. Pp. 153.

The Figure of the Earth. An Introduction to Geodesy. By Mansfield Merriman, Professor of Civil Engineering in Lehigh University. New York: John Wiley & Sons. Pp. 88. $1.50.

Induction Coils: how made and how used. New York: D. Van Nostrand. Pp. 123. 50 cents.

How a Person threatened or afflicted with Bright's Disease ought to live. By Joseph F. Edwards, M. D. Philadelphia: Presley Blakiston. Pp. 87. 75 cents.

The Library. By Andrew Lang. With a Chapter on Modern English Books, by Austin Dobson. London: Macmillan & Co. Pp. 184. $1.25.

Anniversary Memoirs of the Boston Society of Natural History, 1830-1880. Boston: Published by the Society 1880.

Kant and his English Critics. By John Watson, M. A., LL. D. New York: Macmillan & Co. 1881. Pp. 402. $4.00.

A Memorial of Joseph Henry. Published by Order of Congress. Washington: Government Printing-Office. 1880. Pp. 525.

Life of Voltaire. By James Parton. Boston: Houghton, Mifflin & Co. 1881. 2 vols. Pp. 639 and 653. Per vol., $3.

Demosthenes: with Extracts from his Orations, and a Critical Discussion of the Trial on the Crown. By L. Brédif. Translated by M. J. Macmahon, A. M. Chicago: S. C. Griggs & Co. 1881. Pp. 510. $3.

Illustrations of the Earth's Surface-Glaciers. By Nathaniel Southgate Shaler and William Morris Davis. Boston: James R. Osgood & Co. 1881. Folio, pp. 196. Twenty-five Plates, with descriptions. $10.

POPULAR MISCELLANY.

Meeting of the American Association.—The thirtieth meeting of the American Association for the Advancement of Science will be held in Cincinnati, Ohio, beginning August 17th. A large and efficient local committee is making all possible arrangements for the success of the meeting, in order that it may be the largest and most important scientific meeting ever held in the West. Professor G. J. Brush, of New Haven, Connecticut, is President for the year, with Professor A. M. Mayer, of Hoboken, New Jersey, as Vice-President of Section A. The vice-presidency of Section B is vacant, in consequence of the resignation of Dr. Engelmann, who is in Europe. The chairmen of the sub-sections are: of Chemistry, W. R. Nichols, of Boston; of Microscopy, A. B. Hervey, of Taunton, Massachusetts; of Anthropology, Garrick Mallory, of Washington, D. C.; of Entomology, John G. Morris, of Baltimore, Maryland. The changes in the constitution of the Association which were proposed at the Boston meeting will be considered at this meeting. They are intended to enlarge the scope of the Association, and effect a reorganization of the sections, as follows: Section A, Physics; B, Astronomy and Pure Mathematics; C, Chemistry and its applications; D, Mechani-

cal Science; E, Geology and Geography; F, Biology; G, Anthropology; H, Economic Science and Statistics; I, a permanent subsection of Microscopy. The contemplated excursions include one by the Anthropological Section to "Fort Ancient." A loan exhibition of scientific apparatus, appliances, and collections, will be held, in connection with the meeting, by the department of Science and Arts of the Ohio Mechanics' Institute.

The French Association at Algiers.—The French Association for the Advancement of Science met at Algiers, April 14th, and was attended by about fifteen hundred persons, among whom a large proportion of medical men was observed. The opening address was by the President, M. Chauveau, Professor of Physiology in the Lyons Veterinary College, and related principally to the germ theory and Pasteur's theory of fermentation. Several papers on local subjects, chiefly relating to the geology, geography, and demography of Algeria, were read in the general Association, among the results of the presentation of which were the diffusion of much information concerning the colony, and the acquisition of matter which will tend to help its development. One of the most interesting of these papers was by Colonel Playfair, the British consul-general, one of the only two Europeans who have visited their country, on the Kroumirs. Among the papers read in the sections, those in the medical and agronomical sections predominated over all the others. Most of the papers in the mathematical section related to subjects of pure geometry, and several of them were by foreign mathematicians. M. Trepied brought forward a project for the construction of an observatory at Algiers. The most important papers in the section of civil engineering were by Colonel Fourchault, on defensive villages, and by M. Trémaux, on irrigation. Accounts of the lead and iron mines of Tunis, and the copper-mines of the Petit Kabylie, were given in the geological section. Meteorology was well cared for with papers on the meteorology of Asia and of the Sahara, on meteorological instruments, and other related subjects. Among the anthropological papers, which were numerous, were those on the Kabyles, the Tziganes, the Romans in Africa, the Berber migration, the civil, political, and religious institutions of the Jews, and some craniological studies; a prehistoric map of the north of Africa was discussed in this section. The most interesting medical papers were on the epidemics of Algiers, acclimatization, and on the climate of Algiers as regards its influence on consumptive patients. A considerable proportion of the agronomical papers also bore on Algerian interests. Botany, zoölogy, and zoötechny were inadequately represented. The new section of pedagogy was established under the presidency of M. Godard, of the École Monge, in Paris. The working sessions of the Association were shortened in order to give time for the entertainments, some of which were peculiar to the country, and the excursions—to the borders of Tunis, to the country of the Kabyles, to the Sahara, to the boundaries of Morocco, and to interesting spots in the province. Each member of the meeting was presented with a work of scientific, historical, and economical notices of Algiers and Africa; and, whatever else the conference may have done, it has helped to add immensely to the world's knowledge of Northern Africa.

The association has now had a successful career of ten years, and has done some good work. The topics of which it takes cognizance are divided into the four groups of mathematical, physical and chemical, natural and economic sciences, and are considered in sixteen sections.

Hereditary Color-Blindness.—A correspondent has furnished us an account of some remarkable instances of hereditary color-blindness. "I recently heard," she writes, "a very intelligent boy of fourteen speak in this manner: 'Father, you know that green or brown mare of Abe's?' The same lad, speaking of a colored person—'What color?' interrupted a captious listener. 'About that color,' answered the boy, pointing to a jar of pickled cucumbers. The lad, whom I call D——, belongs to a family who have for several generations been troubled with color-blindness. His grandfather was unable to distinguish red, green, and brown, and confounded blue and pink, but always named yellow aright." The

same ancestor was once surprised by hearing some one speak of his father's sleigh as being green on the outside and red on the inside, for it had always appeared to him to be of the same color on both sides. He was also heard to remark that he could see no change in the color of the maple-leaves, which, as we all know, turn from their summer green to red, and then to brown. This form of color-blindness is particularly inconvenient to persons who wish to pick cherries or strawberries, for they have only the forms to guide them, without any help from the color. One of the brothers of the grandfather and two of his first-cousins had the same defect, and a nephew in the next generation. The youth spoken of in the beginning of this notice is the first in the present generation who has manifested it. Generally the affection appears to have been transmitted through the female line of the family, but to sons, and not to daughters. Exceptions to this rule are noticed in the case of a great-uncle of the youth's mother, who inherited it from his father and transmitted it to his four sons; and of a female relative, through whom it was transmitted to two daughters. By means of the instances related, the course of the affection is traced through five generations.

Why Prairies are Treeless.—Mr. Thomas Meehan believes that we have nearly reached the solution of the question of the cause of the absence of trees from the prairies. It is not climatic, for timber-belts flourish in all the prairie regions. It is not in conditions of soil, for the prairie soil is the most favorable to the germination of seeds, of trees as well as of other plants, and artificial plantations are remarkably successful wherever they are made. The real cause is probably to be found in the annual fires which have swept over the prairies from time immemorial, killing the young trees before they can grow large enough to resist the heat. The seeds of the annual plants of the prairie vegetation, maturing every year, are shed and find protection before the fires come; the young trees, on the other hand, bear no seed, and can leave no resource for a succession after they are burned. This theory is supported by the fact that an abundant growth of trees has set in wherever the fires have been stopped. The fires were made by the aborigines for centuries before the white men came, possibly for the express purpose, Mr. Meehan suggests, of preventing the growth of trees and preserving the buffalo-pastures. The question remains how the prairies first came to be naked. They probably formed the bottoms of the lakes and marshes that were left after the retreat of the glaciers, and continued wet after the highlands were covered with trees. Man followed the glaciers so closely that he anticipated the trees on these spots, and, having learned already in southern latitudes the value of burnings, began them before the trees gained a foothold.

Darwin's Views on Vivisection.—The following is Mr. Darwin's reply to a letter from Professor Holmgren, of Upsala, requesting his views on the right to make experiments on living animals in the interest of science:

DOWN, BECKENHAM, *April* 14, 1881.

DEAR SIR: In answer to your courteous letter of April 7th, I have no objection to express my opinion with respect to the right of experimenting on living animals. I use this latter expression as more correct and comprehensive than that of vivisection. You are at liberty to make any use of this letter which you may think fit, but if published I should wish the whole to appear. I have all my life been a strong advocate for humanity to animals, and have done what I could in my writings to enforce this duty. Several years ago, when the agitation against physiologists commenced in England, it was asserted that inhumanity was here practiced, and useless suffering caused to animals; and I was led to think that it might be advisable to have an act of Parliament on the subject. I then took an active part in trying to get a bill passed, such as would have removed all just cause of complaint, and at the same time have left physiologists free to pursue their researches—a bill very different from the act which has since been passed. It is right to add that the investigation of the matter by a Royal Commission proved that the accusations made against our English physiologists were false. From all that I have heard, however, I fear that in some parts of Europe little regard is paid to the sufferings of animals, and if this be the case I should be glad to hear of legislation against inhumanity in any such country. On the other hand, I know that physiology can not possibly progress except by means of experiments on living animals, and I feel the deepest conviction that he who retards the progress of physiology commits a crime against mankind. Any one

who remembers, as I can, the state of this science half a century ago, must admit that it has made immense progress, and it is now progressing at an ever-increasing rate.

What improvements in medical practice may be directly attributed to physiological research is a question which can be properly discussed only by those physiologists and medical practitioners who have studied the history of their subjects; but, as far as I can learn, the benefits are already great. However this may be, no one, unless he is grossly ignorant of what science has done for mankind, can entertain any doubt of the incalculable benefits which will hereafter be derived from physiology, not only by man, but by the lower animals. Look, for instance, at Pasteur's results in modifying the germs of the most malignant diseases, from which, as it so happens, animals will in the first place receive more relief than man. Let it be remembered how many lives and what a fearful amount of suffering have been saved by the knowledge gained of parasitic worms through the experiments of Virchow and others on living animals. In the future every one will be astonished at the ingratitude shown, at least in England, to these benefactors of mankind. As for myself, permit me to assure you that I honor, and shall always honor, every one who advances the noble science of physiology.

Dear sir, yours faithfully,

CHARLES DARWIN.

To Professor HOLMGREN.

Tin in Australia and other Countries.—A German pamphlet by Dr. Eduard Reyer, on "Tin in Australia and Tasmania" (Vienna, 1880), gives some interesting facts relative to the production of tin in different countries outside of Europe. The mining of this metal has become an industry of considerable importance in the Australian colonies. The amount exported from Victoria to England rose from an average of about 130 tons a year between 1860 and 1869, to 2,500 tons in 1877; the production in New South Wales increased from 50 tons in 1872 to 7,000 tons in 1877. Four thousand tons were produced in Queensland in 1874; and the whole amount exported from Australia to England in the first five months of 1877, 1878, and 1879, was respectively 4,300, 4,100, and 2,900 tons. About 4,500 tons were produced in Tasmania in 1877; 4,100 were exported in the first five months of 1878, and 3,300 tons in the corresponding period of 1879. The ore occurs in Australia on the flanks of the mountains which run parallel to the eastern coast, in granite of the Devonian age, and has so far been got by washing from the sediment in the valleys. In Tasmania it is found in the quartz-porphyry of Mount Bischoff, and is likewise obtained by washing. Tin is found in several of the southwestern provinces of China, but it is not so largely produced in that country that considerable quantities are not imported from abroad; it was formerly sent from Java to England; it was extensively mined in the province of Khorassan in Persia; is mentioned as having been formerly produced in Algeria; and is now produced in the Cape Colony at a rate represented by an exportation of about one hundred tons a year. It is found in small quantities or traces in several places in the United States, as in Maine, New Hampshire, Connecticut, Pennsylvania, Virginia, North Carolina, Missouri, and California, and in parts of Mexico, but the whole production of North America is hardly worth speaking of. It is, however, a definite article of production and export in some South American states, as Peru, Chili, and Bolivia; it exists in the province of Minas Geraes in Brazil; and several abandoned tin-mines are mentioned in the Spanish West Indies.

The Glacial Ice-Sheet in the Interior States.—Professor N. H. Winchell suggests, in the "American Journal of Science," that the peculiar formation of ice, which Mr. Dall has described as occurring near Behring Strait (see "Popular Science Monthly" for May, page 130), presents features which may formerly have prevailed in our Western and Northwestern States. Both regions are alike free from high land and rocky hills suited for the production of a glacier. The proof that vast fields of glacier-ice formerly existed over our Northern interior States is now rarely questioned; "and it is highly probable," says Professor Winchell, "that the field explored by Mr. Dall is an epitome, under peculiar and somewhat inexplicable circumstances, of the vaster fields which extended from the Rocky Mountains on the West to the Alleghanies on the East, during the latest epoch of continental ice, the only important exception being that over the continent the southern termination of the ice-sheet was everywhere invisible, and abutted nowhere (in the interior) on the

ocean-shore, so as to reveal its existence. The surface covering of the ice was the surface of the country, and, over many miles north from its actual termination, it supported a varied and even rank vegetation." Professor Winchell observes that the facts reported by Mr. Dall throw light on the manner of formation and deposit of the till, and on the origin of *kames*. The kames are gravel-ridges lying in till-covered countries, occupying the lower situations and generally bordered on either side by a parallel strip of swamp or low land. Now, if we suppose that the till before its deposit lay on the surface of the ice, it is plain that the surface drainage, gathering into streams, would produce deep channels in the ice-sheet, in the bottom of which would be gathered such stones and gravels as the stream could not carry away, and these would gradually sink deeper into the ice, perhaps to the rocky floor itself. When the ice had entirely disappeared, the bed of coarser matters thus formed "would lie undisturbed in its beautiful stratification, where the river produced it"; while on either side would be first the swampy or low land produced by the wash of the stream, and outside of this the unmodified till.

Undergrowth and Forest-Trees.—M. Gourmand has recently described some observations which he has made on the influence of thickets upon the decomposition of vegetable matter and the growth of large trees. A thicket may be formed in the course of eight or ten years after the undergrowth has started; as it rises in height we can at last distinguish between the atmosphere beneath it and the superior atmosphere to which the tops of the larger trees are exposed. Seventeen years of watching and periodical measuring of the growth of the trees of a tract bearing a deciduous undergrowth and a larger coniferous growth have shown that the rate of growth of the larger trees diminishes as the undergrowth becomes more dense; the only exceptions are in glades where the undergrowth sends up vertical limbs instead of spreading out sidewise. The rate of growth thus appears to be modified according as the light is or is not able to penetrate the depth of the wood, and, as carbonic acid is in a corresponding degree more or less rapidly formed from the decomposition of the substances composing the humus. M. Gourmand concludes from these observations that light, when it reaches the ground after passing through foliage, stimulates the production of carbonic acid in decompositions that engender humus in proportion as that gas is decomposed by the green parts; that the growth of the larger trees is retarded, although their green parts stand out in full air and light, where the lower thicket cuts the light off too much from the soil and diminishes its reflex action on their tops; that this effect is governed largely by the arrangement of the limbs of the undergrowth, as it is less marked in glades, where they take a vertical direction; and that the humus under too dense an undergrowth loses a part of its efficiency, and presents an analogy with barn-yard manure, which will remain inert for several years if it is buried too deeply.

The Weather, and Summer Diarrhœas.—Mr. G. B. Longstaff has recently pointed out, in an address before the Society of Medical Officers of Health, some facts concerning the prevalence of summer diarrhœa in England, which are not fully accounted for by the prevailing theories of its origin. He distinguishes between two kinds of diarrhœa: one general, prevailing throughout the year, affecting persons at all ages, and nearly evenly distributed in town and country; and a specific form, which prevails in the summer months and affects most persons at the extremes of life, particularly infants of less than two years old, and which is not definitely modified by changes of season. The second form is, as a rule, a disease of towns, but different towns are differently affected by it. The summer of 1880 was a warm one in England, with the mean temperature in August and September above the average, and a high rainfall in July and September, while little rain fell in August; the death-rate from diarrhœa in England and Wales exceeded the average of the previous ten years by nearly fifty per cent. The comparison of the mortality from this cause in different towns, as between the towns and with the general mortality of the kingdom, failed to establish

such a connection between the changes of temperature and hygrometric conditions and the prevalence of the disease as would be required under the theory that high temperature and drought are primary causes of its production. Out of eleven towns in which the meteorological conditions were recorded, mean temperatures of 60° and upward occurred in June in seven, but in no case was the heat at that time accompanied or immediately followed by numerous deaths from diarrhœa. In nine out of the eleven towns, the highest mean temperature was registered in the first week in September. The epidemic had reached its highest point before that week in four of them. The hot weather continued much longer in London than in Nottingham, yet Nottingham suffered sixty per cent. more severely from diarrhœa than London. The death-rate in Brighton during the last week in July was double that of any other great town for the same week; and "it is a remarkable fact that, although August was hotter and more free from rain than July in London and Brighton, in both towns deaths from diarrhœa diminished in frequency as the month approached its end." Thus, neither the incidence of the disease from week to week nor its distribution in different parts of the country can be explained by meteorological conditions alone; and it is evident that other factors must be taken into account. The events of 1880 as reviewed by him are regarded by Mr. Longstaff as confirmatory, so far as they go, of the theory that the exciting cause of diarrhœa is an organism or some other concomitant of the decomposition of organic matter, which can only exist, or become virulent in its properties, after prolonged high temperature. The fact that lassitude and exhaustion are produced as predisposing conditions to the disease by high temperatures in the early part of the summer does not contradict this theory, but agrees with it fully.

Papuan Women and Feasts.—The *taboo* is in full force in New Guinea, particularly in the restrictions which it imposes on the action of women. They are forbidden to enter the *buambramra*, are excluded from all the feasts, and every dainty which they prepare for the feasts, especially the *keu*, or principal drink, is forbidden to them and to the children. They must not go near the meeting-place of the men, and must instantly flee whenever they hear the sound of music. The only answer given for this exclusion is that, if it were not enforced, the women and children would fall ill and die. The musical instruments of the Papuans are pipes or horns of bamboo, cocoanut-shell, or a peculiar root, which are used to reënforce the voice, a kind of a rattle, and a rude drum. Their feasts are prepared with considerable ceremony, but without noise or confusion, and in a way that shows a remarkable appreciation of the division of labor. Important constituents of the feast are the two favorite drinks, the *munki-la*, which is prepared from the cocoanut, and the *keu*, an extract from the chewed leaves of a plant of the genus *Piper*. The musical instruments are played during the whole feast, as an infallible means of keeping the women and children from disturbing the guests. After all is over, the lower jaw of the pig or dog which has constituted the principal dish is hung up in the *buambramra* as a memento. The *keu* has soporific qualities, and the friends of a Papuan who has taken too much of it are accustomed, in order to keep him awake, to tickle with a stalk of grass the cornea and conjunctiva of his eyes till they become full of tears, and he declares that he no longer feels sleepy. This operation is considered a very pleasant one.

Woman as a Sanitary Reformer.—Dr. B. W. Richardson declares that woman can pursue no nobler occupation than that of attending to the care of health and the prevention of disease within the domestic sphere. This is peculiarly a calling of woman, not only because it agrees with her character and tastes, but also because she is at home and in a position to give it constant attention, while the man is abroad and engaged with other business. The training required for the proper performance of this function is really very simple. A woman can master physiology so far as to understand the general construction of the human body; she can make herself acquainted with its nine great systems, can be taught to comprehend the leading facts bearing on

the anatomy and physiology of those systems, and to understand what part food plays in the economy, the relationships and effects of particular foods, and their relative adaptation to different ages and conditions of the body. Woman should also be acquainted with the construction and operation of the heart and the lungs. Were women trained in the knowledge of elementary truths about the visual function and guided by them, they would see that their children did not assume those positions in study that conduce to short-sightedness and curved spines; if they carefully studied the nature and functions of the skin, they would learn to insist upon the necessity of daily purification by the bath. Woman might also, and ought to, learn all that health requires in the construction and maintenance of the house: to maintain economically within it an equable temperature at all seasons; to keep the air free from dust; to know all about and watch all the drain-pipes, and see that they are kept as systematically clean as the china; to distinguish whether the water is wholesome and agreeable with as much facility as she determines whether the looking-glass is clear; to superintend the purification of the water; and to see that sunlight finds its way into every apartment, and that damp has no place in any one of her rooms. She ought to study the nature and uses of foods, so as to be able not only to make the best selections and carry out the best modes of preparation, but even to introduce new and improved modes of cooking. The knowledge of the diagnosis of disease is not necessary for women except in a limited degree, but they ought to know the correct names and characters of common diseases, to be acquainted with the facts relating to the periods of incubation of those diseases, and to have the best methods of preventing disease at their fingers' ends.

Sound-Signals.—Mr. E. Price-Edwards recently delivered before the Society of Arts a valuable lecture on "Signaling by Means of Sound," in which he considered the requisites of a good signal, and discussed the merits of the different signals in use. The essential quality of a good sound signal is that it shall give a strong sound which can be uniformly heard at a definite distance. The range of a sound is determined by the force with which it is uttered, and is modified by certain conditions of the atmosphere. It is also controlled in part by its musical pitch. The most effective sounds are not found among the very highest pitches, as many imagine, any more than among the very low ones, but appear to lie among the intermediate pitches, to which the ear is best adapted. Bells have been long in use to give signals, but their sounds are curiously fluctuating, and it is not probable that the vibrations from the largest bell are of sufficient intensity to yield a sound capable of overcoming opposing influences, even of a slight nature. Gongs give a distinctive sound, serviceable at a short distance, but it, too, is soon dissipated after leaving the vicinity of the instrument. Gun-signals are of great value, but, according to Professor Tyndall, they can not always be depended upon to overcome local or temporary obstacles to the propagation of sound. It is, moreover, not always convenient to place and manage guns where it is desirable to use them, or to fire them as rapidly as repetition of sound is wanted. Mr. J. R. Wigham, of Dublin, has invented a gas-gun, which can be loaded and fired at a considerable distance from the point of explosion. It consists of a tube of the desired size placed at the point where the signal is to be made, and connected with a gas-main or gas-holder by iron piping. The gun is loaded with an explosive mixture of gas and atmospheric air, fire is applied at the short end of the tube, and the explosion takes place at the mouth of the gun almost immediately. An exceedingly sudden and sharp blow is given to the air, and a sound-wave of great initial intensity is generated by the explosion of gun-cotton. The apparatus employed to explode that substance in the ordinary way is, however, cumbrous, and can not be used conveniently where speedy manipulation is wanted. A rocket has been devised to carry a charge of gun-cotton, or tonite, to a certain height, where it is caused to explode, which has been tested with the most satisfactory effects; from the height of six hundred feet, to which the rocket may be adapted, a direct sound is sent downward into places which would be completely hidden from the level at which a

gun could be fired, and which would seldom be reached by the sound of its discharge. A kind of cartridge of tonite has been made, to be sent high up into the air, explode there, and scatter a shower of brilliant stars, and has been adopted for the purpose of making signals on many vessels. Mr. Price-Edwards does not express a high opinion of whistles; but one of Mr. Courtenay's automatic buoy-whistles has been used off the Goodwin Sands with success, and two others are to be placed off the English coast. The palm of superiority in all respects, as a signal, is accorded to the American siren. Among the improvements that have been made in it are one for increasing the suddenness and intensity of the sound, adaptations for use on ships and steamers, and the double siren, in which two notes are produced simultaneously, the power of the instrument is more than doubled, and a characteristic feature is given to the sound.

The Mékarski Air-Engine.—The Mékarski air-engine, which has been employed satisfactorily for several months on the tramways of Nantes, France, is being introduced into England by the Compressed Air-Engines Company. Both engines combined with the car and simple traction-engines are used at Nantes. In the combined cars and engines, ten cylindrical steel reservoirs for the compressed air are placed beneath the floor, seven of which are united into one system, called the "battery," and the remaining three are united into a second system called the "reserve." Both the battery and the reserve are charged at the principal station with air compressed to thirty atmospheres. The cylinders are placed horizontally in front of the driving-wheels, and are five and three eighths inches in diameter, by ten and a quarter inches stroke. In front of the car, and on the driver's platform, is a small reservoir, which is charged with water, for about two thirds of its capacity, at a temperature of 320°. The air, in passing from the battery or from the reserve to the engines, traverses the water in this reservoir, and thus becomes heated before reaching the cylinders. After doing its work in the cylinders, it passes into a box, from which it escapes into the air. Under this arrangement, which is peculiar to the Mékarski engine, a smaller quantity of air is needed, and the danger of ice forming in the exhaust passages of the cylinder is obviated. A regulating valve on the top of the hot-water reservoir serves to keep the air from the reservoirs at a uniform pressure, whatever may be the variations in the demand by the engines. The combined car, when ready for work, weighs six tons. The traction-engines draw two cars each. The charge of air carried is enough for the whole "round trip."

Stone-Age Civilization in New Guinea.—The Papuans of the Maclay coast, New Guinea, afford a fine and instructive specimen of a living race still in the stone age. The implements on which they have expended their artistic skill come under the two categories of fragments of flint, shells, and bones, and chipped stones in the form of axes. The ornaments upon them are classified by Mr. J. C. Galton, in a notice of M. Maclay's observations, into ornaments made solely for a decorative purpose, ornaments and drawings demonstrating the first beginning of the figurative or ideal style of writing, and ornaments, sketches, and carvings, which stand in close relation to the superstitions and dark religious ideas of the Papuans. The salient character of the ornaments is that they are generally rectilinear, and this is because the bamboo and reed, on which ornamentation was first attempted, do not conveniently admit of any other style of drawing. The style thus fixed on wood was readily transferred to other substances on which decoration was attempted. That the want of variety in subjects of decoration does not proceed from lack of inventive power and skill is shown by the fact that as soon as some of the men got improved tools, such as bits of glass bottles, they introduced refinements and variations into their wood ornamentation. The Papuans have been supposed to be destitute of any art of writing, but M. Maclay believes that he has found evidence of the use by them of an ideograph in a very rude form. He observed rude figures painted in different places in various combinations, the purpose of which puzzled him for a long time, till it was revealed at a feast which was held on the occasion of the

launching of some canoes, on which the natives had been working for a long time. One of the party, during the feast, drew a number of figures resembling those M. Maclay had seen, and evidently referring to the work in hand. The two boats were represented as they were, half on land and half in water; then followed representations of men carrying pigs, the "covers" of the feast, M. Maclay's canoe with its flag, and the canoes of the visiting guests. Further evidence has made it tolerably clear that such representations are real ideographs. The carvings on wood, to which a religious bearing is ascribed, seem to show a regular progress toward sculpture, by the transformation of simple decorations into bas-relief, then into *alto rilievo*, and finally into the complete figure.

Plant-Migrations.—An interesting monograph has been published at the University of Giessen, Germany, on the migrations of two plants, the *Puccinea malvacearum*, or mallows fungus, and the *Elodea Canadensis* (*Anacharis Canadensis*, Gray). The former plant was first noticed infesting the mallows-plants of Chili. It was observed in Spain, for the first time in Europe, in 1869, having, it is thought, been introduced in the course of trade. Next it was found in France, infesting some ten species of the mallows family, in 1872, 1873, and 1874; it appeared in England in 1873, and was carried to Holland and Belgium in 1874. It was also found at the Cape of Good Hope and in Australia in 1874. It began to attract attention in Germany and Italy in 1874, and appears now to be diffused all over Europe, as its presence is mentioned in Bohemia and Hungary and at Athens, which appears so far to mark its southeastern point of extension. The *Elodea*, or *Anacharis Canadensis*, was noticed in single localities in Ireland in 1836 and 1842. Toward 1850 it became quite abundant, and in the course of the next ten years found its way to the Botanical Gardens of Utrecht and the swamps in the neighborhood of Ghent. It was growing in several places in France in 1866. It is now found in considerable abundance in the lower Rhine, the Elbe and its branches, the Havel and Spree, and the Oder. It has extended from Corrib, Ireland, on the west, and Grenoble, France, on the south, to Riga, on the northeast. It has been carried by sprouts to all the places where it grows; for only female plants (not a single male plant) are to be found in all Europe.

Efficiency of Present Causes in Geological Action.—M. Stanislas Meunier has recently published a work discussing the sufficiency of the causes which are still in operation to account for the production of the geological phenomena of the past. Illustrations of the principle involved in the discussion may easily be found in examining some of the formations near the surface. In the section of the coal-beds of Valenciennes, thick, horizontal cretaceous beds appear, resting on carboniferous beds, the strata of which are contorted, bent, and folded neither more nor less than the strata of which the highest mountain-chains are composed. As the contact of the chalk and the coal is horizontal, it must be admitted that, previous to the deposit of the secondary rocks, the ground, which had been greatly disturbed by the foldings of the carboniferous strata, had been again planed down to a level. The first thought would be to attribute the planing down to some sudden and violent action carrying away all of the missing matter at once. The view is entirely changed when we remark that quite as important denudations are taking place now in populous districts without any perturbations of a violent character. Thus, on the British coast of the English Channel the sea is gaining about a yard a year upon the land, and the fact is recognized in sales. The result of this denudation, which is taking place so gradually, can not be distinguished from that of a sudden razing of the strata at the bottom of the sea. M. Meunier examines likewise the theory that river-valleys have been formed by the action of streams in a period of floods, when they were many times larger than the present rivers. The valleys of the rivers, he believes, correspond with original fractures of the soil; this once accepted, we may admit that the stream was neither much more voluminous nor much more rapid in quaternary times than at present. In the course of an indeterminate period of time it has widened

its valley by the operation of the sinuosity of its meanderings, and has covered the whole surface of the soil with detritus. The production of gravel terraces may be attributed to slight elevations of the soil; and many supposed bowlders of considerable dimensions may have been formed by the weathering away of angular blocks. The disappearance of species is now regarded as simply the natural result of the competition of other species; and evidence is not wholly wanting that the introduction of new species is still going on. Thus, a little lizard has been observed quartered on a rock near the Island of Capri which is manifestly derived from a quite different lizard living in the island itself.

NOTES.

Professor Farlow has, at the request of the United States Fish Commission, investigated the cause of the red color which sometimes appears on dried codfish during hot weather, in connection with which it has been noticed that the fish affected by it decayed with comparative quickness. He has found that the redness is owing to a minute plant, the *Clathrocystis roseo-persicina*, which is known in America and Europe, and may sometimes be found tingeing the surface of damp ground with a purplish hue, and in the macerating-tubs of anatomists. It does not appear to flourish or increase very rapidly at a temperature below 65°. It could have been derived from many sources, but Professor Farlow has traced its origin particularly to the salt with which the fish are cured.

George B. Emerson, LL. D., author of the "Report on the Trees and Shrubs growing naturally in the Forests of Massachusetts," died last March, in Boston. He was born in Kennebunk, Maine, in 1797, became known as a teacher, and a writer on educational topics, and has been president of the Boston Society of Natural History.

"Nature" notices a curious confusion in the different senses in which the term *trawling* is used by British and American fishermen. A trawl in England is a large purse-net attached to a heavy beam raised upon trawl-heads, or irons at either end, and dragged along the bottom of the sea. In Scotland it is simply a drift or seine-net. In America it is a long line baited with hooks, and left on the bottom of the sea. Each of the three modes of fishing is objected to in the different countries in which they are employed by men who use one of the others. In Scotland the drift-net fishermen object to the trawl or seine-nets; in England the drift-net and the line fishermen object to the beam-trawlers; in America the hand-line fishermen object to the set-line fishermen, whom they call "trawlers." The complaints are all due to the jealousy usually felt at the introduction of new machinery in any industry; and the Governments of both countries may safely disregard them, since they are the most effective answers to one another.

The fifty-first annual meeting of the British Association will be opened at York, on the 31st of August. The address will be delivered by Sir John Lubbock, President-elect. The presidents of the several sections are: A, Sir W. Thomson; B, Professor A. W. Williamson; C, Professor A. C. Ramsay; D, Professor Owen, in the department of Zoölogy; Professor W. H. Flower, in the department of Anthropology; Professor J. S. Burdon-Sanderson, in the department of Anatomy; E, Sir J. D. Hooker; F, the Right Honorable Grant Duff; G, Sir W. G. Armstrong. Evening addresses will be delivered by Professor Huxley and Sir W. Spottiswoode.

The third meeting of the International Geographical Congress is to be held at Venice, September 15th to 22d. Representatives from all geographical societies are invited to attend, and they will be permitted to speak in any language. The discussions will be held in the eight sections of mathematical geography, geology, and topography; hydrography; physical, geological, meteorological, botanical, and zoölogical geography; anthropological, ethnological, and philological geography; historical geography; economical, commercial, and statistical geography; the study, teaching, and diffusion of geography; explorations and travels. An international geographical exhibition, the schedule of which is very full, and is divided into sections corresponding with those of the Congress, will be held in connection with it, and will be open during September.

Experiments were recently made at the Grand Opéra in Paris in the transmission through the microphone of the musical part of the representation, with results that are described as marvelous. The modulations of the voice and the concerted pieces were distinctly heard and distinguished, to the admiration of the distant audience. A demonstration of this character is expected to form a regular feature at the coming Electrical Exposition, where a special hall will be provided, whence visitors will be able to enjoy the representations at the Opera-House without leaving the place. "La Nature" foresees the day when music will be sent

around by the wires to assembly-rooms, and we will be able to "turn it on" by adjusting a commutator, as we now get water by turning a faucet.

Under the head of "Birds out of Place," Mr. Charles Aldrich, of Webster City, Iowa, records, in "The American Naturalist," that a robin remained last winter on his farm, frequenting a sheltered spot where a little spring of water flowed out of a bank below a mill-dam. He also tells of some crows that were found, during the severe weather, roosting with the chickens, which, for the want of a better shelter, were accustomed to roost in the low branches of a thicket near the house of one of his neighbors. A comparison of many similar observations to those of the robin, which might be recorded if those who made them would take the pains, would probably show that many so-called birds of passage elect to spend the winter in their northern homes, when suitable shelter from violent storms and cold is provided for them, and a supply of food is made accessible.

A Field Club, composed of specialists in various branches of science, and working naturalists, has lately been organized at Des Moines, Iowa. It will publish any results reached which may prove of sufficient value, in the form of occasional bulletins, and proposes, ultimately, to work up the natural history of the entire State, in which little has been done except by individuals, in the shape of local contributions made at their own expense. Geological surveys have been instituted twice, to be abruptly closed by the Legislature before anything of moment could be accomplished. A society like this one can do much to promote a better knowledge of the State, and to awaken a spirit of thorough investigation.

M. Dr. Lemoine has discovered in the lower tertiary beds near Rheims—which were considered nearly if not quite Azoic—fossil remains of an extremely interesting fauna, comprising numerous new species, and even some new genera, of mammals, birds, and reptiles. Many of these species exhibit characters intermediate between those of types which have been heretofore described.

M. G. Trouvé has applied two of his electric motors to an English tricycle, with a gratifying success in making it go. The machines were each fed by three of the accumulators which he uses in his polyscope. The tricycle ran for an hour and a half at the speed of a good carriage. M. Trouvé intends to construct another motor, with which he expects to attain a speed of twelve or sixteen miles an hour.

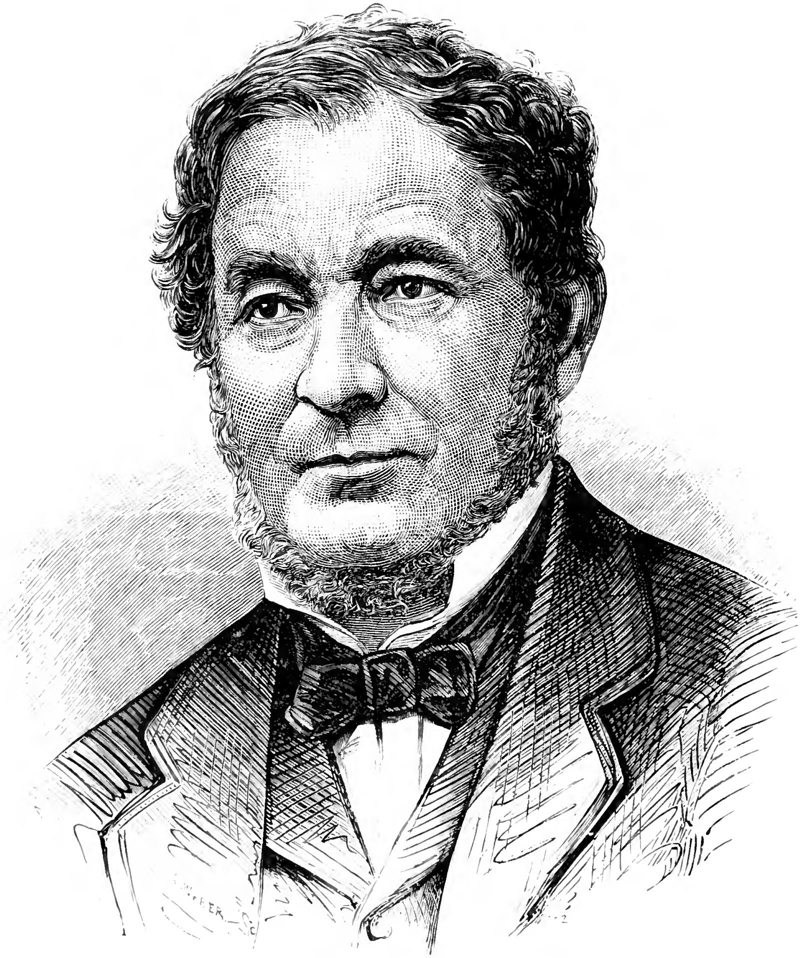
The Appalachian Mountain Club is enjoying an encouraging prosperity. Eighty-five members were added to its list last year, making the whole present number three hundred and twenty. Its position in the community is regarded as established and recognized, and its sphere of usefulness and plans of work as having become in great part well defined and settled. Its library is increasing considerably, by the exchange of its publications for those of other similar societies, which has been undertaken with forty-one societies in Europe, as well as with American organizations. Nine regular meetings were held during 1880, and field-meetings at Plymouth and the Fabyan House, New Hampshire, and several excursions were made. The last number of its journal, "Appalachia," contains, besides the reports, the annual address of President Charles R. Cross on "Barometric Measurement of Heights"; and papers on "Mount Cardigan," by Harold Murdock, and "A Sojourn in Andover, Maine," by Gaetano Lanza.

On the 5th of March last, the main seam of coal in the Ashton Moss Colliery, in Lancashire, England, was cut at the depth of 2,691 feet, or 231 feet lower than the deepest sinking heretofore worked in England, The temperature in the colliery, at the depth of 860 yards, was 78°.

M. de Quatrefages reports that fossil remains of men, well preserved, have been discovered in the quaternary limestones of Nice. M. Desor has determined their geological age, which, it is said, can not be contested; and M. de Quatrefages has determined the race to which they belong as that which has been long known as the Cromagnon race.

Some experiments described by Mr. A. Vogt, in the "Zeitschrift für Biologie," indicate that the southern walls of houses absorb less heat from solar radiation during the day than the eastern and western walls, notwithstanding they are exposed for a considerable longer time to the direct rays of the sun. On a day when the highest temperature of the air was observed at four o'clock in the afternoon, and the maximum of solar radiation at one o'clock, the thermometer behind the eastern wall was highest at eleven o'clock in the morning, behind the southern wall at three, and behind the western at six o'clock in the afternoon.

The Central Meteorological Bureau of France is in telegraphic communication with one hundred and twenty stations in Europe and Northern Africa, over a territory extending from Bodo, in northern Norway, toi Laghore, in southern Algeria, and from the island of Madeira to Moscow.



ROBERT WILHELM BUNSEN.

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THE HERRING.*

By Professor T. H. HUXLEY.

It is now nineteen years since my attention was first specially directed to the natural history of the herring, and to the many important economical and legal questions connected with the herring-fisheries. As a member of two successive Royal Commissions, it fell to my lot to take part in inquiries held at every important fishing-station in the United Kingdom between the years 1862 and 1865, and to hear all that practical fishermen had to tell about the matter; while I had free access to the official records of the Fishery Boards. Nor did I neglect such opportunities as presented themselves of studying the fish itself, and of determining the scientific value of the terms by which, in the language of fishermen, the various conditions of the herring are distinguished.

Diligent sifting of the body of evidence thus collected and passed under review led to the satisfactory clearing away, in my own mind, of some of the obscurities which, at that time, surrounded the natural history of the fish. But many problems remained, the solution of which was not practicable by investigations which, after all, were only incidents in the course of a large inquiry, embracing a vast number of topics besides herrings and herring-fisheries; and it is only within the last few years that the labors of the German West Baltic Fishery Commission have made such large additions to the state of our knowledge in 1865 that the history of the herring is brought within measurable distance of completeness.

Considering the vast importance of the herring-fisheries of the eastern counties, it occurred to me, when the President of the National

* A lecture delivered at the National Fishery Exhibition, Norwich, April 21, 1881.

Fishery Exhibition did me the honor to ask me to address you, that nothing could be more likely to interest my audience than a summary statement of what is now really known about a fish which, from a fisherman's point of view, is probably the chief of fishes.

I am aware that I may lay myself open to the application of the proverb about carrying coals to Newcastle if I commence my observations with a description of the most important distinctive characters of a fish which is so familiar to the majority of my hearers. And perhaps it is as well that I should at once express my belief that most of you are as little likely to mistake a herring for anything else as I am. Nay, I will go further. I have reason to believe that any herring-merchant, in a large way of business, who may be here, knows these fish so much better than I do that he is able to discriminate a Yarmouth herring from a Scotch herring, and both from a Norway herring; a feat which I could not undertake to perform. But then it is possible that I may know some things that he does not. He is very unlike other fishermen and fish-merchants with whom I have met, if he has any but the vaguest notions of the way of life of the fish; or if he has heard anything about those singularities of its organization which perplex biologists; or if he can say exactly how and why he knows that a herring is not a sprat, a shad, or a pilchard. And all kinds of real knowledge and insight into the facts of nature do so bear upon one another and turn out in strange ways practically helpful that I propose to pour out my scientific budget, in the hope that something more may come of it than the gratification of intelligent curiosity.

If any one wants to exemplify the meaning of the word "fish," he can not choose a better animal than a herring. The body, tapering to each end, is covered with thin, flexible scales, which are very easily rubbed off. The taper head, with its underhung jaw, is smooth and scaleless on the top; the large eye is partly covered by two folds of transparent skin, like eyelids—only immovable and with the slit between them vertical instead of horizontal; the cleft behind the gill-cover is very wide, and, when the cover is raised, the large red gills which lie beneath it are freely exposed. The rounded back bears the single moderately long dorsal fin about its middle. The tail-fin is deeply cleft, and on careful inspection small scales are seen to be continued from the body, on to both its upper and its lower lobes, but there is no longitudinal scaly fold on either of these. The belly comes to an edge, covered by a series of sharply-keeled bony shields between the throat and the vent; and behind the last is the anal fin, which is of the same length as the dorsal fin. There is a pair of fore-limbs, or pectoral fins, just behind the head; and a pair of hind-limbs, or ventral fins, are situated beneath the dorsal fin, a little behind a vertical line drawn from its front edge, and a long way in front of the vent. These fins have bony supports or rays, all of which are soft and jointed.

Like most fishes, the herring is propelled chiefly by the sculling action of the tail-fin, the rest serving chiefly to preserve the balance of the body, and to keep it from turning over, as it would do if left to itself, the back being the heaviest part of the fish.

The mouth of the herring is not very large, the gape extending back only to beneath the middle of the eye, and the teeth on the upper and lower jaws are so small as to be hardly visible. Moreover, when a live herring opens its mouth, or when the lower jaw of a dead herring is depressed artificially, the upper jaw, instead of remaining fixed and stationary, travels downward and forward in such a manner as to guard the sides of the gape. This movement is the result of a curious mechanical arrangement by which the lower jaw pulls upon the upper, and I suspect that it is useful in guarding the sides of the gape when the fish gulps the small living prey upon which it feeds.

The only conspicuous teeth, and they are very small, are disposed in an elongated patch upon the tongue, and in another such patch, opposite to these, on the fore part of the roof of the mouth. The latter are attached to a bone called the vomer, and are hence termed vomerine teeth. But, if the mouth of a herring is opened widely, there will be seen, on each side, a great number of fine, long, bristle-like processes, the pointed ends of which project forward. These are what are termed the gill-rakers, inasmuch as they are fixed, like the teeth of a rake, to the inner sides of those arches of bone on the outer sides of which the gills are fixed. The sides of the throat of a herring, in fact, are, as it were, cut by four deep and wide clefts, which are separated by these gill arches, and the water which the fish constantly gulps in by the mouth flows through these clefts, over the gills and out beneath the gill-covers, aërating the blood, and thus effecting respiration, as it goes. But, since it would be highly inconvenient, and indeed injurious, were the food to slip out in the same way, these gill-rakers play the part of a fine sieve, which lets the water strain off, while it keeps the food in. The gill-rakers of the front arches are much longer than those of the hinder arches, and, as each is stiffened by a thread of bone developed in its interior, while, at the same time, its sides are beset with fine sharp teeth, like thorns on a brier, I suspect that they play some part in crushing the life out of the small animals on which the herrings prey.

Between these arches there is, in the middle line, an opening which leads into the gullet. This passes back into a curious conical sac which is commonly termed the stomach, but which has more the character of a crop. Coming off from the under side of the sac and communicating with it by a narrow opening, there is an elogated tubular organ, the walls of which are so thick and muscular that it might almost be compared to a gizzard. It is directed forward, and opens by a narrow prominent aperture into the intestine, which runs straight back to the vent. Attached to the commencement of the intestine

there is a score or more of larger and shorter tubular organs, which are called the pyloric cæca. These open into the intestine, and their apertures may be seen on one side of it, occupying an oval space, in the middle of which they are arranged three in a row.

The chief food of the herring consists of minute crustacea, some of them allied to the shrimps and prawns, but the majority belonging to the same division as the common *Cyclops* of our fresh waters. These tenant many parts of the ocean in such prodigious masses that the water is discolored by them for miles together, and every sweep of a fine net brings up its tens of thousands.

Everybody must have noticed the silvery air-bladder of the herring, which lies immediately under the backbone, and stretches from close to the head to very near the vent, being wide in the middle and tapering off to each end. In its natural state, it is distended with air; and, if it is pricked, the elastic wall shrinks and drives the air out, as as if it were an India-rubber ball. When the connections of this air-bladder are fully explored, it turns out to be one of the most curious parts of the organization of the whole animal.

In the first place, the pointed end of the sac or crop into which the gullet is continued runs back into a very slender duct which turns upward and eventually opens into the middle of the air-bladder. The canal of this duct is so very small and irregularly twisted, that, even if the air-bladder is squeezed, the air does not escape into the sac. But, if air is forced into the sac by means of a blowpipe, the air passes without much difficulty the other way, and the air-bladder becomes fully distended. When the pressure is removed, however, the air-bladder diminishes in size to a certain extent, showing that the air escapes somewhere. And, if the blowing up of the air-bladder is performed while the fish is under water, a fine stream of air-bubbles may be seen to escape close to the vent. Careful anatomical investigation, in fact, shows that the air-bladder does not really end at the point where its silvery coat finishes, but that a delicate tube is continued thence to the left side of the vent, and there ends by an opening of its own.

Now, the air-bladder of all fishes is, to begin with, an outgrowth from the front part of the alimentary canal, and there are a great many fishes in which, as in the herring, it remains throughout life in permanent communication with the gullet. But it is rare to find the duct so far back as in the herring; and, at present, I am not aware that the air-bladder opens externally in any fishes except the herring and a few of its allies.

There is a general agreement among fishermen that herrings sometimes make a squeaking noise when they are first taken out of the water. I have never heard this sound myself, but there is so much concurrent testimony to the fact that I do not doubt it; and it occurs to me that it may be produced, when the herrings are quickly brought

up from some depth, by means of this arrangement. For under these circumstances the air which the air-bladder contains expands to such a degree, on being relieved from the pressure of the water, that deep-sea fishes with a closed air-bladder which are brought to the surface rapidly are sometimes fairly turned inside out by the immense distention, or even bursting, of the air-bladder. If the same thing should happen to the herring, the like misfortune would not befall it, for the air would be forced out of the opening in question, and might readily enough produce the squeak which is reported. The common loach* is said to produce a piping sound by expelling the air which this fish takes into its intestine for respiratory purposes.

At the opposite end of the air-bladder there is an even more curious arrangement. The silvery coat of the air-bladder ends in front just behind the head. But the air-bladder itself does not terminate here. Two very fine canals, each of which is not more than a two-hundredth of an inch in diameter, though it is surrounded by a relatively thick wall of cartilage, pass forward, one on each side, from the air-bladder to the back of the skull. The canals enter the walls of the skull, and then each divides into two branches. Finally, each of these two dilates into a bag which lies in a spheroidal chamber of corresponding size and form; and, in consequence of the air which they contain, these bags may be seen readily enough shining through the side-walls of the skull, the bone of which has a peculiar structure where it surrounds them. Now, these two bags, which constitute the termination of the air-bladder on each side, are in close relation with the organ of hearing. Indeed, a process of that organ projects into the front chamber on each side, and is separated by only a very delicate partition from the terminal sac of the air-bladder. Any vibrations of the air in these sacs, or any change in the pressure of the air in them, must thus tell upon the hearing apparatus.

There is no doubt about the existence of these structures, which, together with the posterior opening of the air-bladder, were most accurately described, more than sixty years ago, by the eminent anatomist Weber; but I am afraid we are not much wiser regarding their meaning than we were when they were first made known. In fishes in general, there can be little doubt that the chief use of the air-bladder is to diminish the specific gravity of the fish, and, by rendering its body of nearly the same weight as so much water, to render the business of swimming easier. In those fishes in which the passage of communication between the air-bladder and the alimentary canal is closed, the air is no doubt secreted into the air-bladder by its vessels, which are often very abundant. In the herring the vessels of the air-bladder are very scanty; and it seems probable that the air is swallowed and forced into the air-bladder just as the loach swallows air and drives it

* See Müller, "Ueber Fische welche Töne von sich geben ("Archiv für Physiologie," 1857, p. 267). The herring is not mentioned in Müller's list of vocal fishes.

into its intestine. And, as I have already suggested, it may be that the narrow posterior canal which leads from the air-bladder to the exterior is a sort of safety-valve allowing the air to escape, when the fish, rapidly ascending or descending, alters the pressure of the water upon the contained air.

This hypothesis may be put forward with some show of probability, but I really find it difficult to suggest anything with respect to the physiological meaning of the connection between the air-bladder and the ear. Nevertheless such an elaborate apparatus must have some physiological importance; and this conclusion is strengthened by the well-known fact that there are a great many fishes in which the air-bladder and the ear become connected in one way or another. In the carp tribe, for example, the front end of the air-bladder is connected by a series of little bones with the organ of hearing, which is, as it were, prolonged backward to meet these bones in the hinder end of the skull. But here the air-bladder, which is very large, may act as a resonator; while in the herring the extreme narrowness of the passages which connect the air-bladder with the ear renders it difficult to suppose that the organ can have any such function.

In addition to the singular connection of the ear with the exterior by the roundabout way of the air-bladder, there are membranous spaces in the walls of the skull by which vibrations can more directly reach the herring's ear. And there is no doubt that the fish is very sensitive to such vibrations. In a dark night, when the water is phosphorescent or, as the fishermen say, there is plenty of "merefire," it is a curious spectacle to watch the effect of sharply tapping the side of the boat as it passes over a shoal. The herrings scatter in all directions, leaving streaks of light behind them, like shooting-stars.

The herring, like other fishes, breathes by means of its gills—the essential part of which consists of the delicate, highly vascular filaments which are set in a double row on the outer faces of each of the gill-arches. The venous blood, which returns from all parts of the body to be collected in the heart, is pumped thence into the gills, and there exchanges its excess of carbonic-acid gas for the gaseous oxygen which is dissolved in sea-water. The freedom of passage of the water and the great size and delicacy of the gills facilitate respiration when the fish is in its native element; but the same peculiarities permitting of the rapid drying and coherence of the gills, and thus bringing on speedy suffocation, render its tenure of life, after removal from the water, as short as that of any fish. It may be observed, in passing, that the wide clefts behind the gill-covers of the herring have some practical importance, as the fish, thrusting its head through the meshes of the drift-net, is caught behind them, and can not extricate itself. In the herring, the upper end of the last gill-cleft is not developed into a sac or pouch, such as we shall find in some of its near neighbors.

The only other organs of the herring, which need be mentioned at present, are the milt and roe, found in the male and female herring respectively.

These are elongated organs attached beneath the air-bladder, which lie, one on each side of the abdominal cavity, and open behind the vent by an aperture common to the two. The spermatic fluid of the male is developed in the milt and the eggs of the female in the roe. These eggs, when fully formed, measure from one sixteenth to one twenty-fifth of an inch in diameter; and as, in the ripe female, the two roes or ovaries stretch from one end of the abdominal cavity to the other, occupying all the space left by the other organs, and distending the cavity, the number of eggs which they contain must be very great. Probably 10,000 is an under-estimate of the number of ripe eggs shed in spawning by a moderate-sized female herring. But I think it is safer than the 30,000 of some estimates, which appear to me to be made in forgetfulness of the very simple anatomical considerations that the roe consists of an extensive vascular framework as well as of eggs; and, moreover, that a vast number of the eggs which it contains remain immature, and are not shed at the time of spawning.

In this brief account of the structure of the herring I have touched only on those points which are peculiarly interesting, or which bear upon what I shall have to say by-and-by. An exhaustive study of the fish from this point of view alone would require a whole course of lectures to itself.

The herring is a member of a very large group of fishes spread over all parts of the world, and termed that of the *Clupeidæ*, after *Clupea*, the generic name of the herring itself. Our herring, the *Clupea harengus*, inhabits the White Sea, and perhaps some parts of the Arctic Ocean, the temperate and colder parts of the Atlantic, the North Sea, and the Baltic, and there is a very similar, if not identical, species in the North Pacific. But it is not known to occur in the seas of Southern Europe, nor in any part of the intertropical ocean, nor in the southern hemisphere.

There are four British fishes which so closely resemble herrings, externally and internally, that, though practical men may not be in any danger of confounding them, scientific zoölogists have not always succeeded in defining their differences. These are the Sprat, the Allice and Twaite Shads, and the Pilchard.

The sprat comes nearest; indeed, young herrings and sprats have often been confounded together, and doubts have been thrown on the specific distinctness of the two. Yet if a sprat and a young herring of the same size are placed side by side, even their external differences leave no doubt of their distinctness. The sprat's lower jaw is shorter; the shields in the middle of the belly have a sharper keel, whence the ventral edge is more like a saw; and the ventral fin lies vertically

under the front edge of the dorsal fin, or even in front of it; while in the herring, though the position of the ventral fin varies a little, it lies more or less behind the front margin of the dorsal fin. The anal fin is of the same length as the dorsal, in the herring, longer than the dorsal in the sprat. But the best marks of distinction are the absence of vomerine teeth in the sprat, and the smaller number of pyloric cæca, which do not exceed nine, their openings being disposed in a single longitudinal series.

Shads and pilchards have a common character by which they are very easily distinguished from both sprat and herring. There is an horizontal fold of scaly skin on each side of the tail above and below the middle line. Moreover, they have no teeth in the inside of the mouth, and their pyloric cæca are very numerous—a hundred or more—their openings being disposed five or six in a row.

The shads have a deep narrow notch in the middle line of the upper jaw, which is absent in the pilchard. The intestine of the shad is short and straight, like that of the herring; while that of the pilchard is long, and folded several times upon itself.

Both of these fishes, again, possess a very curious structure, termed an accessory branchial organ, which is found more highly developed in other fishes of the herring family, and attains its greatest development in a fresh-water fish, the *Heterotis*, which inhabits the Nile. This organ is very rudimentary in the shad (in which it was discovered by Gegenbaur *), but it is much larger in the pilchard, in which, so far as I know, it has not heretofore been noticed. In *Chanos* and several other Clupeoid fishes it becomes coiled upon itself, and in *Heterotis* the coiled organ makes many turns. The organ is commonly supposed to be respiratory in function; but this is very doubtful.

Herrings which have attained maturity, and are distended by the greatly enlarged milt or roe, are ready to shed the contents of these organs, or, as it is said, to spawn. In 1862 we found a great diversity of opinion prevailed as to the time at which this operation takes place, and we took a great deal of trouble to settle the question, with the result which is thus stated in our report:

"We have obtained a very large body of valuable evidence on this subject, derived partly from the examination of fishermen and of others conversant with the herring-fishery; partly from the inspection of the accurate records kept by the fishery officers at different stations, and partly from other sources; and our clear conclusion from all this evidence is, that the herring spawns at two seasons of the year, in the spring and in the autumn. We have hitherto met with no case of full or spawning herrings being found, in any locality, during what may be termed the solstitial months, namely, June and December; and it would appear that such herrings are never (or very rarely) taken in

* "Ueber das Kopfskelet von *Alepocephalus rostratus*" ("Morphologisches Jahrbuch," Bd. iv., Suppl., 1878).

May, or the early part of July, in the latter part of November or the early part of January. But a spring spawning certainly occurs in the latter part of January, in February, in March, and in April ; and an autumn spawning in the latter part of July, in August, September, October, and even as late as November. Taking all parts of the British coast together, February and March are the great months for the spring spawning, and August and September for the autumn spawning. It is not at all likely that the same fish spawn twice in the year ; on the contrary, the spring and the autumn shoals are probably perfectly distinct ; and if the herring, according to the hypothesis advanced above, come to maturity in a year, the shoals of each spawning-season would be the fry of the twelvemonth before. However, no direct evidence can be adduced in favor of this supposition, and it would be extremely difficult to obtain such evidence."*

I believe that these conclusions, confirmatory of those of previous careful observers,† are fully supported by all the evidence which has been collected, and the fact that this species of fish has two spawning-seasons, one in the hottest and one in the coldest months of the year, is very curious.

Another singular circumstance connected with the spawning of the herring is the great variety of the conditions, apart from temperature, to which the fish adapts itself in performing this function. On our own coast, herrings spawn in water of from ten to twenty fathoms, and even at greater depths, and in a sea of full oceanic saltness. Nevertheless, herrings spawn just as freely not only in the narrows of the Baltic, such as the Great Belt, in which the water is not half as salt as it is in the North Sea and in the Atlantic, but even in such long inlets as the Schlei in Schleswig, the water of which is quite drinkable and is inhabited by fresh-water fish. Here the herrings deposit their eggs in two or three feet of water ; and they are found, along with the eggs of fresh-water fish, sticking in abundance to such fresh-water plants as *Potamogeton*.

Nature seems thus to offer us a hint as to the way in which a fish like the shad, which is so closely allied to the herring, has acquired the habit of ascending rivers to deposit its eggs in purely fresh water.

If a full female herring is gently squeezed over a vessel of sea-water, the eggs will rapidly pour out and sink to the bottom, to which they immediately adhere with so much tenacity that, in half an hour, the vessel may be inverted without their dropping out. When spawning takes place naturally, the eggs fall to the bottom and attach themselves in a similar fashion, but at this time the assembled fish dart wildly about, and the water becomes cloudy with the shed fluid of the

* "Report of the Royal Commission on the Operation of the Acts relating to Trawling for Herrings on the Coast of Scotland, 1863," p. 28.

† Brandt and Ratzeburgh, for example, in 1833, strongly asserted that the herring has two spawning-seasons.

milt. The eggs thus become fecundated as they fall, and the development of the young within the ova sticking to the bottom commences at once.

The first definite and conclusive evidence as to the manner in which herring-spawn is attached and becomes developed that I know of was obtained by Professor Allman and Dr. MacBain in 1862,* in the Firth of Forth. By dredging in localities in which spent herring were observed on the 1st of March, Professor Allman brought up spawn in abundance at a depth of fourteen to twenty-one fathoms. It was deposited on the surface of the stone, shingle, and gravel, and on old shells and coarse shell-sand, and even on the shells of small living crabs and other crustacea, adhering tenaciously to whatever it had fallen on. No spawn was found in any other part of the Forth; but it continued to be abundant on both the east and the west sides of the Isle of May up to the 13th of March, at which time the incubation of the ovum was found to be completed in a great portion of the spawn, and the embryos had become free. On the 25th scarcely a trace of spawn could be detected, and nearly the whole of the adult fish had left the Forth.

Professor Allman draws attention to the fact that "the deposit of spawn, as evidenced by the appearance of spent herrings, did not take place till about sixty-five days after the appearance of the herring in the Firth," and arrives at the conclusion that "the incubation probably continues during a period of between twenty-five to thirty days," adding, however, that the estimate must, for the present, be regarded as only approximative. It was on this and other evidence that we based our conclusion that the eggs of the herring "are hatched in at most from two to three weeks after deposition."

Within the last few years a clear light has been thrown upon this question by the labors of the West Baltic Fishery Commission, to which I have so often had occasion to refer.† It has been found that artificial fecundation is easily practised, and that the young fish may be kept in aquaria for as long as five months. Thus a great body of accurate information, some of it of a very unexpected character, has been obtained respecting the development of the eggs, and the early condition of the young herring.

It turns out that, as is the case with other fishes, the period of incubation is closely dependent upon warmth. When the water has a temperature of 53° Fahr., the eggs of the herring hatch in from six to

* "Report of the Royal Commission on the Operation of the Acts relating to Trawling for Herrings on the Coast of Scotland, 1863."

† See the four valuable memoirs, Kupffer, "Ueber Laichen und Entwickelung des Herings in der westlichen Ostsee"; idem, "Die Entwickelung des Herings im Ei"; Meyer, "Beobachtungen über den Wachsthum des Herings"; Heincke, "Die Varietäten des Herings," which are contained in the *Jahresbericht der Commission in Kiel für* 1874–'76—1878. Widegren's essay "On the Herring," 1871, translated from the Danish in U. S. Commission Reports, 1873–'75, also contains important information.

eight days; the average being seven days. And this is a very interesting fact when we bear in mind the conclusion to which the inquiries of the Dutch meteorologists, and, more lately, those of the Scottish Meteorological Society, appear to tend, namely, that the shoals prefer water of about 55°. At 50° Fahr., the period of incubation is lengthened to eleven days; at 46° to fifteen days; and at 38° it lasts forty days. As the Forth is usually tolerably cool in the month of March, it is probable that Professor Allman's estimate comes very near the truth for the particular case which he investigated.

The young, when they emerge from the egg, are from one fifth to one third of an inch in length, and so extremely unlike the adult herring that they may properly be termed larvæ. They have enormous eyes, and an exceedingly slender body, with a yelk-bag protruding from its fore-part. The skeleton is in a very rudimentary condition; there are no ventral fins; and, instead of separate dorsal, caudal, and anal fins, there is one continuous fin, extending from the head along the back, round the tail and then forward to the yelk-bag. The intestine is a simple tube, ciliated internally; there is no air-bladder, and no branchiæ are yet developed. The heart is a mere contractile vessel, and the blood is a clear fluid without corpuscles. At first the larvæ do not feed, but merely grow at the expense of the yelk, which gradually diminishes.

Within three or four days after hatching, the length has increased by about half the original dimensions, the yelk has disappeared, the cartilaginous skeleton appears, and the heart becomes divided into its chambers; but the young fish attains nearly double its first length before blood-corpuscles are visible.

By the time the larva is two thirds of an inch long (a length which it attains one month after hatching), the primitive median fin is separated into dorsal, caudal, and anal divisions, but the ventral fins have not appeared. About this period the young animal begins to feed on small crustacea; and it grows so rapidly that, at two months, it is one and a quarter inch long, and, at three months, has attained a length of about two inches.

Nearly up to this stage, the elongated, scaleless little fish retains its larval proportions; but, in the latter part of the third month, the body rapidly deepens, the scales begins to appear, and the larva passes into the "imago" state—that is, assumes the forms and proportions of the adult, though it is not more than two inches long. After this, it goes on growing at the same rate (eleven millimetres, or nearly half an inch) per month, so that, at six months old, it is as large as a moderate-sized sprat.

The well-known "whitebait" of the Thames consists, so far as I have seen, almost exclusively of herrings, under six months old, and as the average size of whitebait increases, from March and April onward, until they become suspiciously like sprats in the late summer, it may

be concluded that they are the progeny of herrings which spawned early in the year, in the neighborhood of the estuary of the Thames, up which these dainty little fish have wandered. Whether it is the general habit of young herring, even of those which are spawned in deep water, to migrate into the shallow parts of the sea, or even into completely fresh waters, when such are accessible, is unknown.

In the "Report on Trawling" (1863) we observe:

"It is extremely difficult to obtain any satisfactory evidence as to the length of time which the herring requires to pass from the embryonic to the adult or *full* condition. Of the fishermen who gave any opinion on this subject, some considered that a herring takes three, and others that it requires seven years to attain the full or spawning condition; others frankly admitted that they knew nothing about the matter; and it was not difficult, by a little cross-examination, to satisfy ourselves that they were all really in this condition, however strongly they might hold by their triennial or septennial theories. Mr. Yarrell and Mr. Mitchell suppose with more reason that herring attain to full size and maturity in about eighteen months.

"It does not appear, however, that there is any good evidence against the supposition that the herring reaches its spawning condition in one year. There is much reason to believe that the eggs are hatched in, at most, from two to three weeks after deposition, and that in six to seven weeks more (that is at most ten weeks from the time of laying the eggs) the young have attained three inches in length. Now, it has been ascertained that a young smolt may leave a river and return to it again in a couple of months increased in bulk eight or ten fold, and, as a herring lives on very much the same food as a smolt, it appears possible that it should increase in the same rapid ratio. Under these circumstances nine months would be ample time for it to enlarge from three to ten or eleven inches in length. It may be fairly argued, however, that it is not very safe to reason analogically from the rate of growth of one species of fish to that of another; and it may be well to leave the question whether the herring attains its maturity in twelve, fifteen, or sixteen months open, in the tolerably firm assurance that the period last named is the maximum."

On comparing these conclusions with the results of the careful observations of the Baltic Commissioners, it appears that we somewhat over-estimated the rate of growth of the young herring, and that the view taken by Yarrell and Mitchell is more nearly correct. For, supposing that the rate of growth after six months continues the same as before, a herring twelve months old will be nearly six inches long, and at eighteen months eight or nine inches. But full herrings may be met with little more than seven inches long, and they are very commonly found not more than nine inches in length.*

* Ljungman ("Preliminary Report on Herrings and Herring Fisheries on the West Coast of Sweden," translated in United States Commission Report, 1873–'75) speaks of

Fishermen distinguish four states of the herring. Fry or sile, when not larger than sprats; maties, when larger than this, with undeveloped roe or milt; full fish, with largely developed roe or milt; and spent or shotten fish, which have recently spawned.

Herring-fry of the size of sprats are distinguished from full fish not merely by their size, but, in addition, by the very slight development of the milt or roe, and by the accumulation of fat in the abdominal cavity. Bands of fat are found in the mesentery alongside the intestine, and filling up the interspaces between the pyloric cæca.

Maties (the name * of which is a corruption of the Dutch word for a maiden) resemble the fry in these particulars; but, if they are well fed, the deposit of fatty and other nutritive matter takes place, not only about the abdominal viscera, but also beneath the skin and in the interstices of the flesh. Indeed, when nourishment is abundant, this infiltration of the flesh with fat may go so far that the fish can not readily be preserved and must be eaten fresh. The singularly delicate Loch Fyne herrings are in this condition early in the season. When the small crustaceans, on which the maties chiefly feed, are extremely abundant the fish gorge themselves with them to such an extent that the conical crop becomes completely distended, and the Scotch fishermen give them the name of "gut-pock" herrings, as much as to say pouch-gutted fish, and an absurd notion is current that these herrings are diseased. However, the "gut-pock" herrings differ from the rest only in having their pouch full instead of empty, as it commonly is.

As the fish passes from the matie to the full condition, the milt and roe begin to grow at the expense of the nutriment thus stored up; and, as these organs become larger and occupy more and more space in the abdominal cavity, the excess of nutritious substance is transferred to them. The fatty deposit about the intestine and pyloric cæca gradually disappears and the flesh becomes poorer. It would appear that by degrees the fish cease to feed at all. At any rate, there is usually no food in the stomach of a herring which approaches maturity. In all these respects there is the closest resemblance between the history of the herring and that of other fishes such as the salmon—the parr corresponding to the herring-fry or sile, the grilse and the "clean fish" of larger size to the maties.

At length spawning takes place, the accumulated nutrition, transformed into eggs or spermatic fluid, is expelled, and the fish is left in

full herrings ready to spawn, only 100–110 millimetres (four to four and a half inches) long, as observed by himself.

* "Halecum intestina, non modo multa gaudere obesitate, sed et totum corpus eo adeo esse impletum ut aliquando, cum discinditur, pinguedo ex cultro defluat, et præsertim eo quidem tempore ubi halecum lactes aut ova crescere primum incipiunt, unde nostrates eos *Maatgens-Haringen* dicere solent."—A. v. Leeuwenhoek, "Arcana Naturæ," Ep. xcvii (1696).

Leeuwenhoek also mentions having heard of "gut-pock" herrings from Scotch fishermen.

that lean and depauperated state which makes a "shotten herring" proverbial. In this condition it answers to the salmon "kelt," and the milt or roe are now shrunk and flaccid and can be blown up with air like empty bags. If the spent fish escapes its myriad enemies, it doubtless begins to feed again and once more passes into the matie state in preparation for the next breeding-season. But the nature of this process of recuperation has yet to be investigated.

When they have reached the matie stage, the herrings, which are at all times gregarious, associate together in conspicuous assemblages, which are called shoals. These are sometimes of prodigious extent—indeed, eight or nine miles in length, two or three in breadth, with an unknown depth, are dimensions which are credibly asserted to be sometimes attained. In these shoals the fish are closely packed, like a flock of sheep straying slowly along a pasture, and it is probably quite safe to assume that there is at least one fish for every cubic foot of water occupied by the shoal. If this be so, every square mile of such a shoal, supposing it to be three fathoms deep, must contain more than 500,000,000 herrings. And when it is considered that many shoals approach the coasts, not only of our own islands, but of Scandinavia and the Baltic, and of Eastern North America, every spring and autumn, the sum total of the herrings which people our seas surpasses imagination.

If you read any old and some new books on the natural history of the herring, you will find a wonderful story about the movements of these shoals: how they start from their home in the polar seas, and march south as a great armada which splits into minor divisions—one destined to spawn on the Scandinavian, and one on our own shores; and how, having achieved this spawning raid, the spent fish make their way as fast as they can back to their Arctic refuge, there to repair their exhausted frames in domestic security. This story was started in the last century, and was unfortunately adopted and disseminated by our countryman Pennant. But there is not the least proof that anything of the kind takes place, and the probabilities are wholly against it. It is, for example, quite irreconcilable with the fact that herring are found in cods' stomachs all the year round. And the circumstance to which I have already adverted, that practiced eyes distinguish local breeds of herrings, though it does not actually negative the migration hypothesis, is very much against it. The supposition that the herring spawn in the north in the early spring, and in the south in the autumn, fitted very well into the notion that the vanguard of the migrating body of herrings occupied the first spawning-ground it reached, and obliged the rest of the horde to pass on. But, as a matter of fact, the northern herrings, like the southern, have two spawning-times; or perhaps it would be more correct to say that the spawning-time extends from autumn to spring, and has two maxima—one in August-September, and one in February-March.

Finally, there is no evidence that herrings are to be met with in the extreme north of their range, at other times, or in greater abundance, than they are to be found elsewhere.

In the matter of its migration, as in other respects, the herring compares best with the salmon. The ordinary habitation of both fishes is no doubt the moderately deep portion of the sea. It is only as the breeding-time draws near that the herrings (not yet advanced beyond the matie state) gather together toward the surface and approach the land in great shoals for the purpose of spawning in relatively or absolutely shallow water. In the case of the herring of the Schlei we have almost the connecting link between the exclusively marine ordinary herring and the river-ascending salmon.

The records of the herring-fisheries are, for the most part, neither very ancient nor (with the exception of those of the Scotch Fishery Board) very accurately kept; and, from the nature of the case, they can only tell us whether the fish in any given year were readily taken or not, and that may have very little to do with the actual strength of the shoals.

However, there is historical evidence that, long before the time of Henry I, Yarmouth was frequented by herring-fishers. This means that, for eight centuries, herrings have been fished on the English coast, and I can not make out, taking one year with another, in recent times, that there has been any serious fluctuation in their numbers. The number captured must have enormously increased in the last two centuries, and yet there is no sign of diminution of the shoals.

Iu 1864 we had to listen to dolorous prophecies of the coming exhaustion of the Scotch herring-fisheries. The fact that the returns showed no falling off was ascribed to the improvement of the gear and methods of fishing, and to the much greater distances to which the fishermen extend their operations. Yet what has really happened? The returns of subsequent years prove, not only that the average cure of the decade 1869–'78 was considerably greater than that of the previous decade, but that the years 1874 and 1880 are absolutely without parallel in the annals of the Scotch herring-fishery, 1,000,000 barrels having been cured in the first of these years, and 1,500,000 in 1880. In the decade 1859–'68, the average was 670,000 barrels, and the highest 830,000.

In dealing with questions of biology, *a priori* reasoning is somewhat risky, and, if any one tells me "it stands to reason" that such and such things must happen, I generally find reason to doubt the safety of his standing.

It is said that "it stands to reason" that destruction on such a prodigious scale as that effected by herring-fishers must tell on the supply. But again let us look at the facts. It is said that 2,500,000,000, or thereabout, of herrings are every year taken out of the North Sea and the Atlantic. Suppose we assume the number to be 3,000,000,000, so

as to be quite safe. It is a large number undoubtedly, but what does it come to? Not more than that of the herrings which may be contained in one shoal, if it covers half a dozen square miles—and shoals of much larger size are on record. It is safe to say that, scattered through the North Sea and the Atlantic, at one and the same time, there must be scores of shoals, any one of which would go a long way toward supplying the whole of man's consumption of herrings. I do not believe that all the herring-fleets taken together destroy five per cent. of the total number of herrings in the sea in any year, and I see no reason to swerve from the conviction my colleagues and I expressed in our report, that their destructive operations are totally insignificant when compared with those which, as a simple calculation shows, must regularly and normally go on.

Suppose that every mature female herring lays 10,000 eggs, that the fish are not interfered with by man, and that their numbers remain approximately the same year after year, it follows that 9,998 of the progeny of every female must be destroyed before they reach maturity. For, if more than two out of the 10,000 escape destruction, the number of herrings will be proportionately increased. Or, in other words, if the average strength of the shoals which visit a given locality is to remain the same year by year, many thousand times the number contained in those shoals must be annually destroyed. And how this enormous amount of destruction is effected will be obvious to any one who considers the operations of the fin-whales, the porpoises, the gannets, the gulls, the codfish, and the dog-fish, which accompany the shoals and perennially feast upon them; to say nothing of the flat-fish, which prey upon the newly-deposited spawn; or of the mackerel, and the innumerable smaller enemies which devour the fry in all stages of their development. It is no uncommon thing to find five or six—nay, even ten or twelve—herrings in the stomach of a codfish,* and in 1863 we calculated that the whole take of the great Scotch herring-fisheries is less than the number of herrings which would in all probability have been consumed by the codfish captured in the same waters if they had been left in the sea.†

Man, in fact, is but one of a vast coöperative society of herring-catchers, and, the larger the share he takes, the less there is for the rest of the company. If man took none, the other shareholders would have a larger dividend, and would thrive and multiply in proportion, but it would come to pretty much the same thing to the herrings.

* In his valuable "Report on the Salt-Water Fisheries of Norway" (1877), Professor Sars expresses the belief that full-grown codfishes feed chiefly, if not exclusively, on herrings.

† In 1879 rather more than 5,000,000 cod, ling, and hake, were taken by the Scottish fishermen. Allowing each only two herrings a day, these fishes would have consumed more than 3,500,000,000 of herrings in a year. As to the Norwegian fisheries, 20,000,000 codfishes are said to be taken annually by the Loffoden fishermen alone.

As long as the records of history give us information, herrings appear to have abounded on the east coast of the British Islands, and there is nothing to show, so far as I am aware, that, taking an average of years, they were ever either more or less numerous than they are at present. But, in remarkable contrast with this constancy, the shoals of herrings have elsewhere exhibited a change capriciousness—visiting a given locality for many years in great numbers, and then suddenly disappearing. Several well-marked examples of this fickleness are recorded on the west coast of Scotland; but the most remarkable is that furnished by the fisheries of Bohüslan, a province which lies on the southwestern shore of the Scandinavian peninsula. Here a variety known as the "old" or "great" herring, after being so extremely abundant, for about sixty years, as to give rise to a great industry, disappeared in the year 1808, as suddenly as they made their appearance, and have not since been seen in any number.

The desertion of their ordinary grounds by the herring has been attributed to all imaginable causes, from fishing on a Sunday to the offense caused to the fish by the decomposing carcasses of their brethren, dropped upon the bottom out of the nets. The truth is, that absolutely nothing is known on the subject, and that little is likely to be known until careful and long-continued meteorological and zoölogical observations have furnished definite information respecting the changes which take place in the temperature of the sea, and the distribution of the pelagic crustacea which constitute the chief food of the herring-shoals. The institution of systematic observations of this kind is an object of international importance, toward the attainment of which the British, Scandinavian, Dutch, and French Governments might wisely make a combined effort.

A great fuss has been made about trawlers working over the spawning-grounds of the herring. "It stands to reason," we were told, that they must destroy an immense quantity of the spawn. Indeed, this looked so reasonable that we inquired very particularly into a case of the alleged malpractice which was complained of on the east coast of Scotland, near Pittenweem. Off this place there is a famous spawning-ground known as the Traith hole, and we were told that the trawlers worked vigorously over the spot immediately after the herring had deposited their spawn. Of course our first proceeding was to ask the trawlers why they took the trouble of doing what looked like wanton mischief. And their answer was reasonable enough. It was to catch the prodigious abundance of flat-fish which were to be found on the Traith at that time. Well, then, why did the flat-fish congregate there? Simply to feed on herring-eggs, which seem to be a sort of flat-fishes' caviare. The stomachs of the flat-fish brought up by the trawl were, in fact, crammed with masses of herring-eggs.

Thus every flat-fish caught by the trawl was an energetic destroyer

of herring arrested in his career. And the trawling, instead of injuring the herring, captured and removed hosts of their worst enemies. That is how "it stood to reason" when one got to the bottom of the matter.

I do not think that any one who looks carefully into the subject will arrive at any other conclusion than that reached by my colleagues and myself: namely, that the best thing for governments to do in relation to the herring-fisheries is, to let them alone, except in so far as the police of the sea is concerned. With this proviso, let people fish how they like, as they like, and when they like. At present, I must repeat the conviction we expressed so many years ago, that there is not a particle of evidence that anything man does has an appreciable influence on the stock of herrings. It will be time to meddle when any satisfactory evidence that mischief is being done is produced.—*Nature.*

PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

RECREATION.

"Mirth is a remedy."—Thomas Hobbes.

HAPPINESS is the normal condition of every living creature, for in a state of nature every normal function is connected with a pleasurable sensation. "To enjoy is to obey"; if human life were what it could be and what its Author intended it to be, the path of duty would be a flowery path, the reward of virtue would not be a crown of thorns; man, like all his fellow-creatures, would attain to his highest well-being by simply following the promptings of his instincts. Wild animals have not lost their earthly paradise; he who has observed them in the freedom of their forest homes can not doubt that to them existence is a blessing, and death merely the later or earlier evening of a happy day. Nor would our missionaries find it easy to persuade an able-bodied savage that earth is a vale of tears, till fire-water and fire-arms demonstrate the superiority of revelation over the light of nature. The children of the wilderness need no holidays; to them life itself is a festival and earth a play-ground for manifold games, not the less entertaining for being sometimes spiced with danger or prompted by hunger and thirst.

But in process of time the daily life of a combatant in the harder and harder struggle for existence became so joyless and wearisome that the clamors of an unsatisfied instinct suggested the institution of periodical festivals: pleasure-days intended to offset the tedium of monotonous toil, as gymnastic exercises tend to counteract the influ-

ence of sedentary occupations. The Assyrians and Greeks had tri-monthly holidays, besides annual revels, and great national festivals at longer intervals. In ancient Etruria every new month was ushered in by a day of merrymaking in honor of a tutelary deity; the patricians and plebeians of republican Rome had their field-days; the festivals of the seasons united the pleasure-seekers of all classes, and even the slaves had their Saturnalia weeks when some of their privileges were only limited by their capacity of enjoyment. In the first centuries of the Roman Empire, when the growth of the cities and the scarcity of game began to circumscribe the private pastimes of the poorer classes, the rulers themselves provided the means of public amusements; at the death of Septimus Severus (A. D. 211), the capital alone had six free amphitheatres and twelve or fourteen large public baths, where the poorest were admitted gratis, and none but the poorest could complain about the half-cent entrance-fee to the luxurious *thermæ*. The *circenses*, or public games, were by no means confined to the gladiatorial combats that have exercised the eloquence of our Christian moralists; dramatic entertainments, trials of strength, and the exhibition of outlandish curiosities, seem to have been as popular as the grandest prize-fights, unless the combatants were international champions. And it would be a great mistake to suppose that only the wealthy capital could afford to amuse its citizens at the public expense; from Gaul to Syria every town had a circus or two, every larger village an arena, a free bath, and a public gymnasium. The Colosseum of Vespasian seated eighty thousand spectators, but was rivaled by the amphitheatres of Narbonne, Syracuse, Antioch, Berytus, and Thessalonica.* Children, married women, old men, and many trades-unions had their yearly carnivals, and, during the celebration of the Olympian and Capitoline games and various local festivals, even strangers enjoyed the freedom of the larger towns.

And now?—Professor Wirgmann, in his "Annalen des Russischen Reiches," estimates that since the accession of Nicholas I, the modern Cæsars have expended an average annual sum of seventeen million dollars for the torture of their subjects; how many cents have they ever spent for national pastimes? How many spectators (since the abolition of the "Tyburn-days") have ever been entertained at the expense of the wealthy British Empire? What has our Great Republic done in the matter of *circenses*, except to pass an occasional sabbath law for the suppression of public amusements on the only day in which a large plurality of our workingmen find their only leisure for recreation? The spoils of a Roman consul would dwindle before the rents of our American, German, and French financiers: what have our commercial triumphators ever achieved for the entertainment of their poor fellow-citizens? Cooper Institute lectures, street revivals, and prize distributions at the examination of a sabbath-school for adults?

* Tacitus, "Annalen," xii–xiv.

"At the proposition of such-like pastime," says Ludwig Boerne, "a resurrected citizen of ancient Rome would feel like a filibuster at an invitation to dive for copper coins in a duck-pond, after having chased King Philip's silver fleet on the Spanish Main."

Not poverty makes our daily ways so trite and joyless, for the best recreations are still as free as the air and the sea; nor want of leisure, for we manage to find plenty of time for humdrum ceremonies. The old Egyptians turned their funerals into holidays—we celebrate our holidays like funerals; all the employments of our weekly day of rest are sicklied over with a cast of superstitious fear; and, indeed, no other anachronism of our strangely complex civilization proclaims more loudly the necessity of its divorce from the influence of an anti-natural religion. When that religion reigned supreme, its exponents openly and violently waged war upon all earthly joys; sublunary life, according to their doctrine, was a state of probation for testing a man's power of self-denial; earth was the devil's own, and delight in its pleasures an insult to the jealous ruler of a higher sphere. They believed that God delights in the self-abasement and mortification of his creatures, and hoped to gain his favor by afflicting themselves in every possible way—by voluntary seclusion, fasts, vigils, the wearing of dingy garments, and abstinence from every physical pleasure. Failing to enamor mankind with their doleful heaven, they revenged themselves by depriving them of their earthly joys. In hopes of making the hereafter more attractive, they made life as repulsive as possible; kill-joys and persecutors were the active heroes of those times; ascetics and self-tormentors their passive exemplars. Virtue and joylessness became synonyms; men aspiring to superior merit exchanged the glories of the sunny earth for the misery of a gloomy convent; a "Man of Sorrows" became a type of moral perfection, an instrument of torture, the trade-mark of the new religion. *Kosmos*—i. e., beauty and harmony—was the oldest Grecian term for God's wonderful world; a "vale of tears" the favorite Christian epithet. A symposium of festive heroes was exchanged for a conventicle of whining penitents, Olympus for a charnel-house, the festival of the seasons for the ecclesiastic sabbath: there, a merry multitude, joining in dances and heroic games, inspired by the rapture of emulation, the joy of exuberant health and the beauty of earth till their happiness overflowed in anthems of praise to the bounteous gods; here, a cowed and wretched assemblage, listening with groans to the denunciations of a Nature-hating fanatic. And that hideous superstition founds its claim to our gratitude on its merit of having suppressed a few profligate pastimes—in aiming its death-blows at all earthly joys whatever; as if the crushing of a few poison-plants could atone for the attempt to turn a fertile continent into a sand-waste! The attempt, I say, for I do not believe that either the axe or the cross will for ever mar the beauty of our Mother Earth; the devastated woodlands of the East will ulti-

mately be reclaimed, and here and there the moral desert of asceticism has already begun to bloom with flowers from the revived seeds of Grecian civilization.

Monachism, at least, is fast disappearing; in this age of railroads and steam-engines we have no time for positive self-torture *à la Simon Stylites.* But our commercial Pecksniffs have found it a time- and money-saving plan to stick to the negative part of the anti-pleasure dogma, and hope to atone for the dreary materialism of our daily factory-life by the still drearier asceticism of a Puritan sabbath: six days of misery in the name of Mammon, balanced by one day of sixfold misery in the name of Christ. "Worldly pleasures" are still under the ban of our spiritual purists; daily drudgery and daily self-denial are still considered the proper sphere of a law-abiding citizen, and special afflictions a special sign of divine favor. Life has become a socage-duty; we do not think it necessary to alleviate the distress of our poor till it reaches a degree that threatens to end it. We have countless benevolent institutions for the prevention of outright death, not one benevolent enough to make life worth living. Infanticide is now far more rigorously punished than in old times; we enforce every child's right to live and become a humble, tithe-paying Christian, but as for its claim to live happy we refer it to the sweet by-and-by. We shudder at the barbarity of the Cæsars, who permitted the combat of men with wild beasts, to cater to the amusement of the Roman populace; but we contemplate with great equanimity the misery of millions of our fellow-citizens, wearing away their lives in workshops and factories; millions of children of our own nation and country, who have no recreation but sleep, no hope but oblivion, to whom the morning sun brings the summons of a taskmaster and the summer season nothing but lengthened hours of weary toil; nay, we make it the boast of our pious civilization to deprive them of their sole day of leisure, to interdict their harmless sports, lest the noise, or even the rumor of their merriment, might disturb the solemnity of an assemblage of whining hypocrites. Hence the recklessness, the Nihilism, and the weary pessimism of our times, the melancholy that everywhere underlies the glittering varnish of our social life. Hence also that vague yearning after a happy hereafter, which the murderers of the happy past have made the principal source of their revenues.

With few exceptions the children of Christendom are stricken with a disease which mirth alone can cure. In North America and North Britain, especially, it is pitiful to witness the slow withering of so many light-loving creatures in the hopeless night of poverty and sabbatarianism; more pitiful to see the reviving of their spirits at every deceptive sign of dawn, the expedients of poor, compromising Nature, her makeshifts with half-recreations and half-sufficient rest, in the lingering hope of a better future—to come only with the repose from which no factory-bell can awaken a sleeper, when after long years of

waning life, waning at last to a state of callous vegetation, Nature is reduced to the alternative of ending an evil for which she has no remedy.

But while the ebb of life alternates with a tide, the struggle against a natural instinct is the struggle of Prometheus against the vulture of Jove; in the intervals of torment the martyr may forget his misery, but the torturer returns, and the poisoned arrows of the interventor can bring only a temporary relief. Man can not conquer a God-sent instinct, though he may for a time defy it—with poison; the most incurable victims of intemperance are those who resort to stimulants less for the sake of intoxication than for the benumbing after-effect which helps them to stifle the voice of outraged Nature. It is a significant circumstance that the consumption of intoxicating poisons increases in times of famine and general distress; the Christian dogma of the reformatory value of misery has, indeed, been refuted by the most dreadful arguments of the world's history; the unhappiest nations are not only the most immoral, but the most selfish and the meanest in every ugly sense of the word: virtues do not flourish on a trampled soil. The same with individuals; injustice, disappointment, and bodily pain, can turn the noblest man into a querulous tyrant, a harmless kitten into a spiteful cat. Happiness, on the other hand, is the sunshine that decks the moral world with flowers; making earth a heaven would be the surest way of turning men into angels; the hardest heart will melt under the persistent rays of kindness and happiness. Happy children have no time to be wicked; it is not worth their while to waste the merry hours on vices. Genius, too, is a child of light; the Grecian worship of joy favored the development of every human science, while the monastic worship of sorrow produced nothing but monsters and chimeras; for to modern science Christianity bears about the same relation as the plague to the quarantine.

But, aside from all this, mirth has an hygienic value that can hardly be overrated while our social life remains what the slavery of vices and dogmas has made it. Joy has been called the sunshine of the heart, yet the same sun that calls forth the flowers of a plant is also needed to expand its leaves and ripen its fruits; and without the stimulus of exhilarating pastimes perfect bodily health is as impossible as moral and mental vigor. And, as sure as a succession of uniform crops will exhaust the best soil, the daily repetition of a monotonous occupation will wear out the best man. Body and mind require an occasional change of employment, or else a liberal supply of fertilizing recreations, and this requirement is a factor whose omission often foils the arithmetic of our political economists.

To the creatures of the wilderness affliction comes generally in the form of impending danger—famine or persistent persecution; and under such circumstances the modifications of the vital process seem to operate against its long continuance; well-wishing Nature sees her

purpose defeated, and the vital energy flags, the sap of life runs to seed. On the same principle an existence of joyless drudgery seems to drain the springs of health, even at an age when they can draw upon the largest inner resources ; hope, too often baffled, at last withdraws her aid ; the tongue may be attuned to canting hymns of consolation, but the heart can not be deceived, and with its sinking pulse the strength of life ebbs away. Nine tenths of our city children are literally starving for lack of recreation ; not the means of life, but its object, civilization has defrauded them of ; they feel a want which bread can only aggravate, for only hunger helps them to forget the misery of *ennui*. Their pallor is the sallow hue of a cellar-plant ; they would be healthier if they were happier. I would undertake to cure a sickly child with fun and rye-bread sooner than with tidbits and tedium.

Mirth is a remedy ; the remarkable longevity of the French aristocrats,* in spite of their dietetic and other sins, can with certainty be ascribed to the gayety of their pastimes ; almost any mode of diversion is better than the deadly monotony of our sabbatarian machine-life ; even excursion-trains have added years to the average longevity of our city populations. In a temperature of — 56° Fahr., Elisha Kane kept his men in good health by devoting a part of the long night to burlesques and pantomimes ; but, as a sanitary precaution, dramaturgy was only collateral to the substitution of tea for grog ; and the most striking illustration of the hygienic effect of merriment is therefore, perhaps, the experience of Dr. Brehm, the manager of the Hamburg Zoölogical Garden. Having noticed that the monkeys in the happy-family department generally outlived the solitary prisoners, he concluded to try the Swiss nostalgia-remedy, "fun and cider-punch" ; but the liquid stimulants proved superfluous : the introduction of a grapple-swing and a few toys sufficed to reverse the shadow on the dial of death, and man by man the quadrumana recovered from a disease which evidently had been nothing but *ennui*, since the mortuary lists of the last decade showed an almost uniform death-rate throughout the year, except in midsummer, when the monkey-house could be thoroughly ventilated.

Men of a cheerful disposition are generally long-lived, and anything tending to counteract the influence of worry and discontent directly contributes to the preservation of health. Despair can paralyze the energy of the vital functions like a sudden poison, while the fulfillment of a long-cherished hope has effected the cure of many dis-

* E. g., Polignac, eighty-one years ; Richelieu, eighty-three ; Sainte-Pierre, seventy-eight ; Chateaubriand, eighty ; Lafayette, seventy-eight ; Duke of Bassano, eighty-one ; Corneille, eighty ; Dumouriez, eighty-four ; Palinet, eighty-five ; Fontenelle, one hundred ; Joinville, ninety-one ; L'Enclos, eighty-nine ; La Maintenon, eighty-four ; Rochefoucauld, eighty ; Villars, eighty-one ; Sully, eighty-one ; Montfaucon, eighty-six ; Soult, eighty-two ; Talleyrand, eighty-four.

eases; history abounds with examples of strong men dying of sheer grief,* as well as of a great success giving to others a new lease of life. Even hope can sustain the vital powers under severe trials; the appearance of a distant sail or a leeward coast has often restored the strength of shipwrecked sailors who would have succumbed to another hour of hopeless famine. A mere day-dream of a possible deliverance from toil or captivity prolongs the life of thousands who would not survive an awakening to the realities of their situation.

But "hope deferred" sickens the body as well as the soul; and, next to the happiness of a life whose labors are their own immediate reward, is the confident anticipation of a period of compensating enjoyments at the end of every day, of every week, and every year, or part of a year. With a few playthings the youngsters of the nursery will find pastimes enough, though even the youngest should have some corner of the house where they can feel quite at home; but the necessity of providing special times and modes of recreation begins with the day when a child is delivered to the taskmaster, when its employment during any considerable part of the twenty-four hours becomes laborious and compulsory. Children under ten should never be kept at school for more than three consecutive hours, unless the variety of the successive lessons forms itself a sort of recreation, as drawing after grammar, or writing alternating with "calisthenics" or vocal exercises. If the principal meal of the day is taken at noon, the mid-day recess should be extended to at least three hours; otherwise one hour is more than sufficient, especially where the recess sports are diverting enough to forget the schoolroom for a few minutes. The more completely a special train of thoughts can for a while be dismissed from the mind, with the more profit can it afterward be resumed, for the same reason that the successful practice of any bodily exercise requires a periodical relaxation of the strained muscles. But, if the instinct of rooks and savages can be trusted, the recreation-time, *par excellence*, is the evening hour; and with a little management young and old bondmen of drudgery might consecrate the end of every day to health-restoring sports. All schools ought to close at 4 P. M.; and, till we can enforce the eight-hours labor law, the societies for the prevention of cruelty should liberate at least the younger factory-slaves two hours before the sunset of a summer day, in order to give them a chance for a few minutes' recreation between supper and bedtime. "*Horas non conto, nisi serenas*" was the usual inscription of the Roman sun-dials, but the Arabs of the desert count time by nights instead of days; and for us, too, sunset is the beginning of the most pleasant and most play-inviting hour of the twenty-four; the day's work is done, no fear of interruption damps the merriment of the moment, and to the fatigue

* E. g., Isocrates, Kepler, Mehemet Ali, Bajazet, Politianus, Columbus, Maupertuis, Pitt, the two Napoleons, Nicholas I, Joseph II, Platen, Abd-el-Kader, Shamyl, Horace Greeley.

of boisterous sports the coming night offers the refuge of rest and sleep. For the same reason the compulsory somnolence of our Quaker-sabbath makes Saturday night the Saturnalia-time of many Christian nations; the Sunday laws have reduced them to amusements which can, and too often ought to, dispense with daylight, and in the larger cities apprentices and factory-boys have the alternative of joining in such night revels or postponing their amusements to the musical resurrection of the saints in light, for the free Saturday is unfortunately confined to primary schools and a few private seminaries. In German schools Saturday is at least a half-holiday; i. e., the scholars are dismissed at noon, and at once make for the fields and woods, except in winter, when the disciples of the Turnerhall assemble on the last afternoon in the week.

With our present helplessness against the lethargic influence of the midsummer heat, the conventional time of the long vacations is well selected, but, if a hoped-for diet and dress reform shall have taught us to pass the dog-days with comfort, it would be more sensible to divide the two months: four free weeks in June, in time for the first huckleberries and butterflies, and four in October—the best season for a long excursion to the paradise of a primitive mountain-range, nowadays about the only sanctuary of Nature where her worshipers can shake their shoulders free from the yoke of prejudice and escape from the atmosphere of hypocrisy to a higher and purer medium. For the children of the poor every city should have a *Kinder-park*—not a ceremonious promenade, with sacred groves and unapproachable grass-plots, but a public play-ground with shade-trees and swings, May-poles, gymnastic contrivances and a free bathing-house, and room for all the free menageries and music-halls which the Peabodies of the future might feel inclined to add. Inactivity is no recreation; we should not spend our leisure hours like machines, whose best relief is a temporary surcease of toil, but like living creatures of the God who intended that the joys of life should outweigh its sorrows. Let us provide healthful pastimes, or the victims of asceticism will resort to vices—dram-drinking, gambling, and secret sins—for even pernicious excitements become attractive as a relief from the insupportable dullness of a canting Quaker life.

Ennui has never made a human being better or more industrious; on the contrary, the hope of a merry evening would inspire a day-laborer with a good-humor and an energy unknown to the languid *resignados* of our present system. The confident expectation even of a physical pleasure imparts to the current of life an onward impulse that seems to react on the mind as well as on every function of the automatic organism; the first Napoleon, who enlivened the tedium of camp-life with Olympic festivities, and did not deem it below his dignity to make his own *maître de plaisir*, could in return rely on his men to endure fatigues that would have killed the barrack-slaves of

his enemies. It is not hard work that drives our young men to seek a Lethe in alcohol: we read of Grecian soldiers marching fifty miles a day in heavy armor; of hunters running down a wild-boar, and of teamsters yoking themselves to a car when their horses had broken down. Many of our New England boys, who go on a whaling cruise rather than die of *ennui*, would gladly consent to work, in the ancient sense of the word, if they could exchange their Pecksniff-day for a Grecian festival. The Aryan nations, too, had their sacred days and sacred rites, but their Nature-worship was the mist that rises from the woods and meadows, and blends with the ethereal hues of the sky; the Hebrew priestcraft dogma is a poison-cloud which for centuries has darkened the light of the sun and blighted the fairest flowers.

In choosing the mode of a child's recreations, it should be borne in mind that their main purpose is to restore the tone of the mind and its harmony with the physical instincts by supplying the chief deficiencies of our ordinary employment. For a hard-working blacksmith, fun, pure and simple, would be a sufficient pastime, while brain-workers need a recreation that combines amusement with physical exercise—the unloosening of the brain-fiber with the tension of the muscles. Emulation and the presence of relatives and schoolmates impart to competitive gymnastics a charm which a spirited boy would not exchange for the passive pleasure of witnessing the best circus-performance. Wrestling, lance-throwing, archery, base-ball, and a well-contested foot-race, can awaken the enthusiasm of the Grecian *palæstra*, and professional gymnasts will take the same delight in the equally healthful though less dramatic trials of strength at the horizontal bar. But, on the play-ground, such exercises should be divested from the least appearance of *being a task*—even children can not be happy on compulsion.

There is also too much in-door and in-town work about the present life of our schoolboys. Encourage their love of the woods; let us make holidays a synonym of picnic excursions, and enlarge the definition of camp-meetings; of all the known modes of inspiration, forest air and the view of a beautiful landscape are the most inexpensive, especially from a moral standpoint, being never followed by a splenetic reaction. A ramble in the depths of a pathless forest, or on the heights of an Alpenland, between rocks and lonely mountain-meadows, opens well-springs of life unknown to the prisoners of the city tenements.

But the chief curse of our in-door life is, after all, its dullness; and its direct antidote merriment, therefore the chief point about all real recreations. Fun and laughter have become the most effective cordials of our materia medica, and their promotion a most important branch of the science of happiness. There is no such thing as genuine frolic in the stifling atmosphere of a stove-room; the shady lawn in summer and the open hall in winter make a better play-ground than the stuffy nurs-

ery; but freedom from restraint is a still more essential element of mirth. Even in the despotic countries of the Old World the representative of the Government attends the public *fêtes* in disguise, and, if the schoolmaster wants to watch the recess-sports of his pupils, let him do so unobserved; if you can trust your children at all, trust them not to abuse the freedom of their recreations, or else conduct your surveillance as unobtrusively as possible. Children detest ceremonies; in our etiquette-ridden towns too many boys are aliens under their fathers' roof; give them one hour in the day and one corner in the house where they are really at home, where they can feel that the permission to enjoy themselves is granted as a right rather than as a concession to the foibles of youth. If I had to board my children in an old hull, like Anderson's sea-shell peddler, I would let them store their toy-shells in the caboose, and keep it sacred from the intrusion of the forecastle folk, to let my little ones know that the believers in the divinity of joy, though in a sad minority in this pessimistic world, have rights and perquisites which I mean to maintain against all comers.

It does not cost much to make the little folks happy; time, and permission to use it, is all the most of them ask; but make them sure that the pursuit of happiness is not a contraband affair, but a legitimate and praiseworthy business. Nor can it do any harm to let them accumulate a little stock in trade—marbles, tops, dolls, and magic lanterns, and, if possible, a few pets; in winter-time, and for the bigger boys, a private menagerie of squirrels and gophers is a better aid to domestic habits than a hundred interviews with the home-missionary. Connive at a snowball-fight or a torn hat; and be sure that a pair of skates, fishing-tackle, and a base-ball outfit are a better investment than a medicine-chest. Make your children happy; all Nature proclaims the plan of a benevolent Creator; let them feel that their life is in harmony with that plan—that existence has a positive value, an attraction that would remain, though the fear of death were removed.

And, above all, let no cloud of superstition darken the sunshine of your Sundays; and, in countries where the kneil of the church-bells drives your children from the play-grounds of the city, take them out to the woods and mountains, and let them worship the Creator in his grandest temple; teach them to love his day by making it the happiest day in the week. Or, disregard the bells and brave the consequences: till we can repeal the sabbath laws, let us defy them in every way and at any risk; in dealing with the despotism of the mythology-mongers, legal obligations are out of the question; the right of Nature enters the lists against the right of brutal force leagued with imposture.

THE BLOOD AND ITS CIRCULATION.

By HERMAN L. FAIRCHILD.

THE main facts of blood circulation have been known only two hundred and fifty years. This would be surprising if we were not aware that most of our certain knowledge in natural history, including many truths of easier discovery than the circulation of the blood, has been gained within the last one hundred years. And, indeed, the blood and its movements are not yet fully understood. Several points which, at first thought, would seem of easy solution, are matters in dispute or confessed mysteries. The purpose of this article is, not to publish new truth or discuss difficult points, but to compactly present the fundamental and interesting facts relating to the circulation in all animals.

The necessity of a circulating nutritive fluid lies in the localizing of the process of digestion. In proportion as digestion and absorption of food become specialized and restricted to certain parts, circulation becomes more important in order to convey that food to the tissues, and carry from the tissues the worn-out material. To maintain the character of the fluid, it must itself undergo constant change, and hence the excretory processes—respiration being the most urgent—which increase the necessity for movement of the fluid. Circulation of the nutritive fluid is the immediate function for upbuilding and repairing the body. It harmonizes the several vegetative functions, and should be regarded as the primary function, to which all the others are subservient.

The amœba, sponge, and tapeworm have no blood; they have no necessity for it, as they are destitute of digestive organs, their food being in immediate contact with all parts of the body: or, we might regard their blood as simply the water or fluid in which the animal is immersed. In animals possessing the simplest digestive cavities, as the jelly-fish and sea-anemone, the blood is merely the dissolved food, corresponding to the *chyme* of higher animals. In the starfish, sea-urchin, and other invertebrates, having a complete and distinct stomach, the blood is *chyle;* while in vertebrates the blood is a distinct fluid, chemically very complex, difficult of analysis, and not perfectly understood: structurally, it is essentially the same in all animals—a clear fluid containing organic particles.

The blood contains all the nourishment which supports the various tissues of the whole structure. It may properly be regarded as the fundamental tissue, and is well named in the French *chair coulant*—running flesh. It changes rapidly by eating, exercise, and any influence which affects the supply of nutriment or the waste of the body. It is derived primarily from the new food, received in the higher ani-

mals chiefly through the lacteals and veins of the stomach; secondly, from the waste of the body received through the lymphatics and thoracic duct; and, thirdly, through respiration, which supplies oxygen. The amount of solid matter seems to bear a proportion to the amount of flesh in the diet and to the temperature of the animal, being greater in the carnivorous and warm-blooded animals.

In color, the blood of all vertebrates is red, excepting that of the

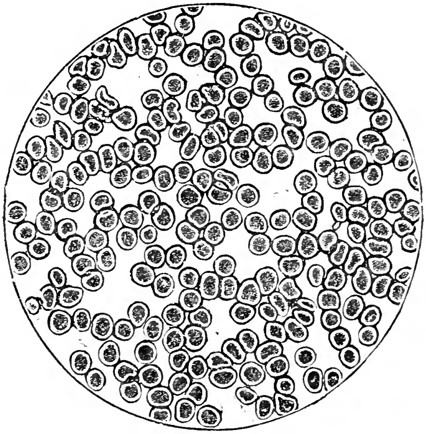


FIG. 1.—HUMAN BLOOD-CORPUSCLES; magnified 370 diameters.

amphioxus, the lowest animal of the sub-kingdom, which is colorless. In the muscles of fishes it is also white. In the invertebrates the blood is of various colors, but commonly white, on account of which fact they were formerly supposed to be destitute of blood.

Microscopic examination of the blood of a vertebrate animal shows that the color is due to an immense number of red particles floating in a watery fluid. But the shape and size of these corpuscles vary in the different groups of vertebrates, and in different species. In man, and all mammals excepting the camel tribe, the red corpuscles are biconcave disks. In the camel they are elliptical. The corpuscles in all other vertebrates are nucleated, or have a thickened center. Those of birds, reptiles, and amphibians are elliptical, while those of fishes are discal, elliptical, or angular.

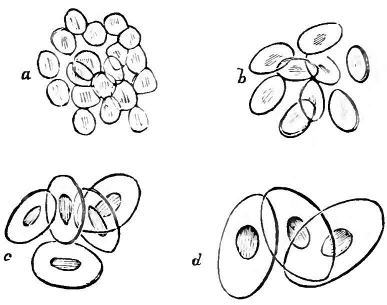


FIG. 2.—BLOOD-CORPUSCLES (relative size). *a*, Man; *b*, Blenny; *c*, Frog; *d*, Newt.

The size of the red blood-corpuscles bears little relation to the size of the animal, except within the natural groups, as the orders of mam-

mals and the class of birds. The largest are found in the amphibians, those of the *proteus* being $\frac{1}{400}$ of an inch in diameter. The smallest are found in the musk-deer, being $\frac{1}{12000}$ of an inch. Those of the ostrich are $\frac{1}{1600}$ of an inch, and of the humming-bird $\frac{1}{3000}$ of an inch. Yet this tiniest of vertebrates equals, in the size of its blood-corpuscles, the largest of living creatures, the bulky whale. Those of man are from $\frac{1}{3000}$ to $\frac{1}{3500}$ of an inch. The value of microscopic measurements of blood-corpuscles, as evidence in legal cases, has been

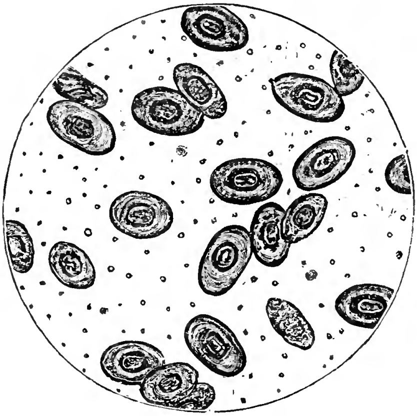


Fig. 3.—Blood Corpuscles of the Frog; magnified 370 diameters, showing the nucleus.

much overrated. It is quite impossible to distinguish human blood from that of the dog, and, without very extensive measurements, from that of some other mammals.

These red corpuscles are frequently larger than the capillary tubes through which they have to pass, but, on account of their elasticity, they squeeze through and afterward regain their shape.

It is estimated that a drop of human blood contains one million corpuscles—a late authority says five millions—in a cubic millimetre.

In addition to the red corpuscles of the vertebrates, all true blood contains colorless corpuscles. These are nucleated in the vertebrates, mollusks, and higher articulates. They are usually smaller than the red, and not nearly so numerous. They vary rapidly in number according to changes in the body or blood, and may bear a proportion to the red of one in one thousand to one in three hundred. Although generally globular, they have no fixed shape, but have amœboid movements. Indeed, the resemblance is so close between the amœba and these white corpuscles, that Professor Huxley, in defining the amœba, says it is structurally "a mere colorless blood-corpuscle leading an independent life." And again he says: "Leaving out the contractile vacuole, the resemblance of an *amœba* in its structure, manner of moving, and even of feeding, to a colorless corpuscle of the blood of one of the higher animals is particularly noteworthy"; also in a foot-note

to this, "contractile vacuoles have been observed in the colorless blood-corpuscles of *amphibia* under certain conditions." Is it possible that the human body is an aggregation or colony of low individuals, something like a sponge? It is believed that the red corpuscles are produced from the white, being only their modified nuclei. They are more numerous in the capillaries and veins. The death and reproduc-

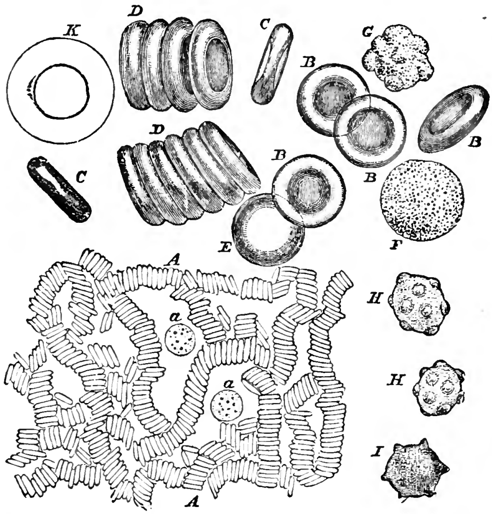


Fig. 4.—Red and White Corpuscles of Human Blood greatly magnified. A, red corpuscles, lying in rows like rolls of coin; at *a* and *a* are seen two white corpuscles. B, red corpuscles more highly magnified, seen in face; C, the same in profile; D, the same in rows more highly magnified; E, a red corpuscle swollen into a sphere by absorption of water. F, a white corpuscle magnified same as B. G, the same, throwing out some blunt processes; K, the same, treated with acetic acid, showing nucleus, magnified the same as D. H, red corpuscles puckered or crenate all over; I, the same, at the edge only.

tion of the blood-corpuscles are rapid and constant. Dr. Draper estimates that twenty millions die at every breath. In transfusion of the blood of a bird into a mammal, the bird-corpuscles soon disappear.

Upon exposure to the air the fibrine of the blood hardens, and, entangling the corpuscles, forms the *clot*, leaving a yellowish liquid called *serum*. The composition of the blood may be graphically shown as follows:

Liquid blood	Corpuscles	Colored	Clot	Coagulated blood.
		Colorless		
	Plasma, or Liquor sanguinis	Fibrine		
		Serum	Albumen	
			Serosity = water and salts	

Coagulation serves in nature the purpose of stopping wounds. It is providentially more rapid in the lower animals, as they have no artificial means of arresting the flow of flood; and quite instantaneous in insects. What prevents the blood from coagulating during life, or in the blood-tubes, is unsettled. It can be prevented by salt.

The temperature of the blood depends upon the rapidity with

which the blood is oxidized; and, within natural orders, it has a relation to the activity of the animal. For example, that of the swallow is 111°, hen 109°, gull 100°; among mammals, squirrel 105°, cat 101°, dog 99°, man 98°. The animals called cold-blooded are only relatively so, for fishes and reptiles have a temperature somewhat above that of the water or air in which they live. Even the lower creatures are slightly warmer than the surrounding medium.

The weight of the blood, which is always greater than that of water, depends, of course, upon the amount of solid matter and the abundance of the corpuscles. In man, the red corpuscles constitute one third to a little less than one half the mass of the blood. The blood of birds has the largest proportion; and it appears that the temperature bears a relation to the amount of solid matter.

The amount of blood is greater in warm-blooded animals; and the *proportion* of blood to the size of the body increases with the size. The blood of man is by weight about one thirteenth the weight of the body. The dog has blood equal to one fifteenth its body-weight; rabbit, one eighteenth; cat, one twenty-first. The amount of blood in the elephant and the whale has not been determined; but the heart of the whale is three feet in diameter.

The operation of transfusing the blood of a living animal into the vessels of another, or of one that is dying, was known in ancient times, and has been practiced at intervals for the last three hundred years. Extravagant hopes concerning it were formerly entertained. It was believed that diseases might be cured, impaired reason restored, old age deferred, and even the dead returned to life. In late years the eminent Brown-Séquard states that a dead dog was by this means restored to life for twelve hours; but the experiment has never been confirmed, and doubtless the animal was not dead, as supposed. It is also stated that a maniac was restored to reason by the blood of a calf.

In modern medical science, the transfusion of blood has become a well-recognized operation for cases of exhaustion from simple loss of blood. For this it is frequently practiced, and with success in the majority of cases. For general weakness and disease it has sometimes been used, but has not proved reliable.

The amount of blood used in transfusion is usually a very few ounces, sometimes only one or two drachms—rarely ten or more ounces; a small quantity is safer. The blood of a different species of animal is considered dangerous when used in large quantity. Venous blood is preferred, and may or may not be defibrinated.

Pure milk has been successfully used instead of blood; and even artificial mixtures are employed. Richardson kept a monkey alive for several weeks by a daily injection of an artificial blood.

The veins of the extremities are generally selected for the operation, they being less likely to admit air, which might be fatal by causing coagulation.

From what has already been stated as the purpose of circulation, we should not expect to find any circulation in those animals which are destitute of a separate digestive cavity ; and in such we do not discover a true blood-circulation. But it would appear that no animal is entirely without the power of distributing its food to the parts of the body. In the amœba this is accomplished by the movements of the protoplasmic body, whereby the portions which have enwrapped and dissolved food-particles are blended with the less nourished parts. The "contractile vesicles" of the amœba may also have to do with the distribution of nourishment, though they are usually regarded as respiratory or excretory in function.

Next to this, in simplicity, is the prolongation of the digestive cavity for the distribution of food. This is found in various animals of different classes. The jelly-fish has a system of four canals, radiating from the imperfect stomach, and uniting with a circular canal at the margin of the body. We may regard this as the earliest development of organs for conveying nutriment. A similar condition exists in the anemone ; and spiders have prolongations of the stomach in addition to their circulating organs.

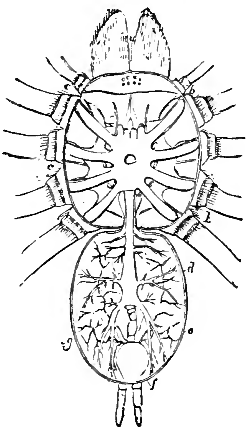


Fig. 5.

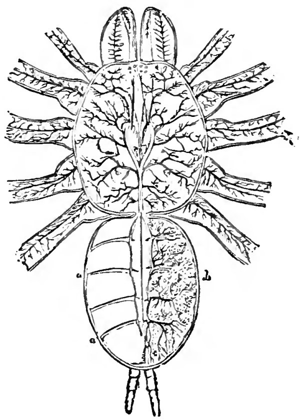


Fig. 6.

Circulation of the Spider Mygale Blondii. Fig. 5.—The stomach, with its cæca and the remainder of the alimentary canal, with the liver and Malpighian tubes. Fig. 6.—Heart and arterial vessels.

True circulation is found only with a complete separation of the digestive cavity from the visceral or general body cavity. In many invertebrates there is simply a flux and reflux of nutritive fluid in this visceral cavity, but no special circulating vessels. This is the condition in the bryozoa, the lowest of mollusks, in the rotifera, and in the larvæ of certain myriapods and insects. In these the fluid is more the nature of chyle, and is called the chylaqueous fluid.

The "circulating system is gradually developed as an offset of the visceral cavity." This is shown by the low ascidian mollusks, in

which there is a sinus system prolonged from the visceral cavity, but freely communicating with it. In this system the chylaqueous fluid flows alternately in either direction, being propelled by a pump or rudimental heart, which is only a muscular portion of one of these sinuses. The same condition is found in some low crustaceans and arachnids, and in the larvæ of certain insects.

In former articles the sea-urchin has been noticed as the lowest possessor of true teeth and stomach, and we now have to award it the added honor of the first distinct heart and blood-vessels.

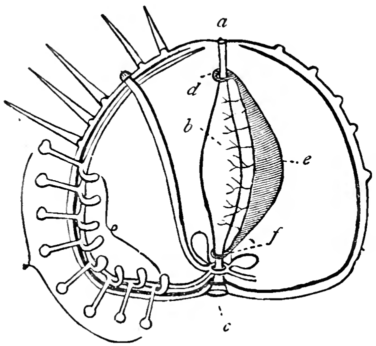


FIG. 7.—DIAGRAM OF SEA-URCHIN. *a*, Anus; *b*, Stomach; *c*, Mouth; *e*, Heart, which by vascular rings encircles the alimentary canal at *d* and *f*.

The more highly organized invertebrates have a muscular heart and true arteries. But the blood always enters the visceral cavity before returning to the heart. In other words, there is no closed current in the invertebrates, the system of circulating vessels being in direct communication with the body cavity. Regarding the circulation of the lower invertebrates, there is still much uncertainty, as various sets of vessels are found in different groups, the purpose of which is obscure, and their relation to the blood-circulation a matter of investigation. The great variety in the circulation of the many groups of invertebrates renders a detailed description impossible. It will be consonant with the present purpose to briefly describe only a few typical forms.

The typical system of the articulates is simply a segmented vessel

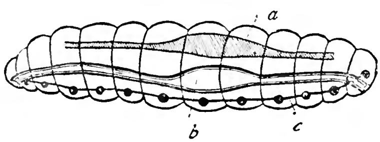


FIG. 8.—DIAGRAM OF ARTICULATE ANIMAL. *a*, Heart or Blood System; *b*, Digestive System; *c*, Nervous System.

lying lengthwise in the back of the animal. This dorsal tube, trunk, or "heart," is open at both ends, and has openings along the sides, guarded by valves. The chylaqueous fluid fills the body cavity, bathing the heart and all the viscera. A puncture of the skin alone allows the blood to issue. The walls of the tubular heart are muscular and pulsatile. When the heart expands, the nutritive fluid is drawn in at the hinder end and lateral apertures, and upon contraction it is forced forward and escapes at the forward end, being prevented by valves from flowing backward or escaping laterally. The

fluid finds its way backward through the lacunæ or passages between the tissues and viscera. The dorsal vessel prevents the stagnation of the fluid.

In the myriapods the dorsal trunk has as many segments as there are joints of the body. One of the millepeds has not less than one hundred and sixty. Centipeds have generally twenty-one segments, and besides the pair of valves for each joint there is given off a pair of arteries. These unite to form a ventral tube. Insects have the heart segmented only in the abdomen, and never more than eight segments. An arterial prolongation of the trunk as a simple tube extends to the head.

As spiders and scorpions have localized breathing-sacs, they require a respiratory circulation. This is secured, not by special tubes, but by the passage of the blood, on its return to the heart, through venous sinuses or special passages between the internal organs.

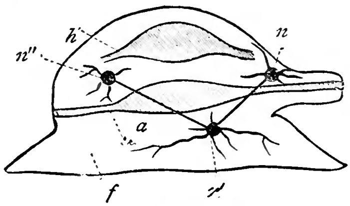


Fig. 9.—Diagram of Mollusk. *a*, Alimentary Canal; *h*, Heart; *n*, *n'*, *n''*, Nervous Ganglia.

The best heart among articulates is possessed by the crustaceans, the largest, though not the highest, animals of the sub-kingdom. Crabs and lobsters have a concentrated heart, a short, fleshy sac, with great propelling power, which sends the blood by several branching arteries to the parts of the body. We now find a concentration of the power which had been previously diffused in a long tube.

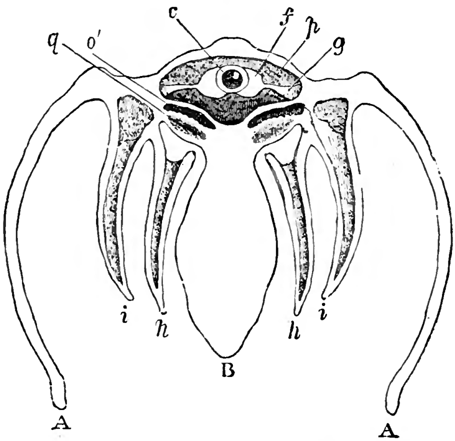


Fig. 10.—Cross-sectional Diagram of a Fresh-water Mussel. *f*, Ventricle; *g*, Auricles; *c*, Rectum; *p*, Pericardium; *h*, *i*, Gills; B, Foot; A, A, Mantle or Skin.

As the mollusks are mostly so sluggish that their circulation has little aid from the movements of the body, they require a more pow-

erful pump. In the higher mollusks the heart has generally two cavities—an auricle for receiving the blood and a ventricle for propelling it. The bivalve mollusks have generally two auricles. In the mollusks we discover a well-developed capillary system, but the venous or return circulation is still partly lacunar. The heart of invertebrates is always systemic—it forces the blood to the body, not to the breathing-organs. But some of the cephalopod mollusks, the so-called devil-fishes, have contractile cavities at the bases of the gills, which act the part of a pulmonary heart, forcing the blood through the breathing-organs on its way to the true heart. These accessory hearts are called *branchial hearts*.

[*To be continued.*]

THE TEACHINGS OF MODERN SPECTROSCOPY.*

By Dr. ARTHUR SCHUSTER, F. R. S.

A SCIENCE, like a child, grows quickest in the first few years of its existence; and it is therefore not astonishing that, though twenty years only have elapsed since Spectrum Analysis first entered the world, we are able to speak to-day of a modern spectroscopy, with higher and more ambitious aims, striving to obtain results which shall surpass in importance any of those achieved by the old spectroscopy, to the astonishment of the scientific world.

A few years ago the spectroscope was a chemical instrument. It was the sole object of the spectroscopist, to find out the nature of a body by the examination of the light which that body sends out when it is hot. The interest which the new discovery created in scientific and unscientific circles was due to the apparent victory over space which it implied. No matter whether a body is placed in our laboratory or a thousand miles away—at the distance of the sun or of the farthest star—as long as it is luminous and sufficiently hot, it gives us a safe and certain indication of the elements it is composed of.

To-day, we are no longer satisfied to know the chemical nature of sun and stars; we want to know their temperature, the pressure on their surface; we want to know whether they are moving away from us or toward us; and, still further, we want to find out, if possible, what changes in their physical and chemical properties the elements with which we are acquainted have undergone under the influence of the altered conditions which must exist in the celestial bodies. Every sun-spot, every solar prominence, is a study in which the unknown quantities include not only the physical conditions of the solar surface,

* Address delivered at the Royal Institution of Great Britain, January 28, 1881.

but also the possibly changed properties, under these conditions, of our terrestrial elements. The spectroscope is rapidly becoming our thermometer and pressure-gauge; it has become a physical instrument.

The application of the spectroscope to the investigation of the nature of celestial bodies has always had a great fascination to the scientific man as well as to the amateur; for in stars and nebulæ one may hope to read the past and future of our own solar system. But it is not of this application that I wish to speak to-day.

As there is no other instrument which can touch the conditions of the most distant bodies of our universe, bodies so large that their size surpasses our imagination, so is there no other instrument which equals it in the information it can yield on the minute particles at the other end of the scale, particles which in their turn are so small that we can form no conception of their size or number. The range of the spectroscope includes both stars and atoms, and it is about these latter that I wish to speak.

The idea that all matter is built up of atoms, which we can not further divide by physical or chemical means, is an old one. As a scientific hypothesis, however—that is, an hypothesis which shall not only qualitatively, but also quantitatively, account for actual phenomena—it has only been worked out in the last thirty years. The development of molecular physics was contemporaneous with that of spectroscopy, but the two sciences grew up independently. Those who strove to advance the one paid little attention to the other, and did not trouble to know which of their conclusions were in harmony, which in discordance, with the results of the sister science. It is time, I think, now that the bearing of one branch of inquiry on the other should be pointed out: where they are in agreement, their conclusions will be strengthened, while new investigations will lead to more perfect truths where disagreement throws doubt on apparently well-established principles.

What I have ventured to call modern spectroscopy is the union of the old science with the modern ideas of the dynamical theory of gases, and includes the application of the spectroscope to the experimental investigation of molecular phenomena, which without it might for ever remain matters of speculation or of calculation.

A body, then, is made up of a number of atoms. These are hardly ever, perhaps never, found in isolation. Two or more of them are bound together, and do not part company as long as the physical state of the body remains the same. Such an association of atoms is called a molecule. When a body is in the state of a gas or vapor, each molecule for the greater part of the time is unaffected by the other molecules in its neighborhood, and therefore behaves as if these were not present. The gaseous state, then, is the one in which we can best study these molecules. They move about among each other, and

within each molecule the atoms are in motion. Each atom, again, has its own internal movement. But, if the world were made up of atoms and molecules alone, we should never know of their existence; and, to explain the phenomena of the universe, we must recognize the presence of a continuous universal medium penetrating all space and all bodies. This medium, which we call the luminiferous ether, or simply the ether, serves to keep up the connection between atoms or molecules. All communications from one atom to another, and from one molecule to another, are made through this ether. The internal motions of one atom are communicated to this medium, propagated through space, until they reach another atom; attraction, repulsion, or some other manifestation takes place; and, if you examine any of the changes which you see constantly going on around you, and follow it backward through its various stages, you will always find the motion of atoms or molecules at the end of the chain.

The importance of studying the motion of molecules is therefore clear; and it is the special domain of the modern spectroscopy to investigate one kind of these motions.

When a tuning-fork or a bell is set in vibration, its motion is taken up by the surrounding air, waves are set up, they spread and produce the sensation of sound in our ears. Similarly, when an atom vibrates, its motion is taken up by the ether, waves are set up, they spread, and if of sufficient intensity produce the sensation of light in our eyes. Both sound and light are wave-motions. A cursory glance at a wave in water will lead you to distinguish its two most prominent attributes. You notice at once that waves differ in height. So the waves both of light and sound may differ in height, and to a difference in height corresponds a difference in the intensity of the sound you hear or of the light you see. The higher the wave the greater its energy, the louder is the sound or the brighter is the light. But, in addition to a difference in height, you have noticed that in different waves the distance from crest to crest may vary. The distance from crest to crest is the length of the wave, and waves not only differ in height but also in length. A difference in the length of a wave of sound corresponds to a difference in the pitch of the sound; the longer a sound-wave is, the lower is the tune you hear. In the case of light a difference in the length of the wave corresponds to a difference in the color you see. The longest waves which affect our eyes produce the sensation of red, then follow orange, yellow, green, blue, and the shortest waves which we ordinarily see seem violet. If a molecule vibrates, it generally sends out a great number of waves which vary in length. These fall together on our retina, and produce a compound sensation which does not allow us to distinguish the elementary vibrations, which we want to examine. A spectroscope is an instrument which separates the waves of different lengths before they reach our retina; the elementary vibrations, after having passed through a spectroscope, no longer

overlap, but produce their impressions side by side of each other, and their examination and investigation is therefore rendered possible.

The elements of spectroscopy will be familiar to most of you, but you will forgive me if I briefly allude to some points, which, though well known, are of special importance in the considerations which I wish to bring before you to-night.

When a body is sufficiently hot it becomes luminous, or, to speak in scientific language, the vibrations which are capable of producing a luminous sensation on our retina are increased in intensity as the temperature is raised, until they produce such a sensation. By means of a strong electric current I can in the electric lamp raise a piece of carbon to a high temperature. When looked at with the unaided eye it seems whitehot, but, when I send the rays through a prism and project them, as I do now, on a screen, you see a continuous band of light. This fact we express by saying that the spectrum of the carbon poles in the electric lamp is a continuous one. You see side by side the different colors known to you by the familiar but incorrect name of "the rainbow-colors"; and the experiment teaches you that the carbon pole of the electric lamp sends out rays in which all wave-lengths which produce a luminous sensation are represented.

But, if now I introduce into the electric arc a small piece of a volatile metal, you see no longer a continuous band of light. The band is broken up into different parts. Narrow bands or lines of different colors are separated by a space sometimes black, sometimes slightly luminous. The metal has been converted into vapor by the great heat of the electric current, and the vibrations of its molecules take place in distinct periods, so that the waves emanating from it have certain definite lengths. If the molecule could only send out one particular kind of waves, I should in its spectrum only see one single line. We know of no body which does so, though we know of several in which the possible periods of vibration are comparatively few; the spectrum of these will, therefore, contain a few lines only. Thus we have two different kinds of spectra, continuous spectra and line-spectra. But there is a certain kind intermediate in appearance between these two. The spectra of "fluted bands," as they are called, appear, when seen in spectroscopes of small dispersive powers, as made up of bands, which have a sharp boundary on one side and gradually fade away on the other. When seen with more powerful instruments, each band seems to be made up of a number of lines of nearly equal intensity, which gradually come nearer and nearer together as the sharp edge is approached. This sharp edge is generally only the place where the lines are ruled so closely that we can no longer distinguish the individual components. The edge is sometimes toward the red, sometimes toward the violet, end of the spectrum. Occasionally, however, the fluted bands do not show any sharp edge whatever, but are simply made up of a series of lines which are, roughly speaking, equi-

distant. No one who has seen a spectrum of fluted bands can ever fail to distinguish it from the other types of spectra which I have described.

What, then, is the cause for the existence of these different types? The first editions of text-books in which our science was discussed stated that a solid or liquid body gave a continuous spectrum, while a gaseous body had a spectrum of lines; the spectra of bands were not mentioned. The more recent editions give a few exceptions to this rule, and the editions which have not appeared yet, will—so I hope, at least—tell you that the state of aggregation of a body does not directly affect the nature of the spectrum. The important point is not whether a body is solid, liquid, and gaseous, but how many atoms are bound together in a molecule, and how they are bound together. This is one of the teachings of modern spectroscopy. A molecule containing a few atoms only gives a spectrum of lines. Increase the number of atoms, and you will obtain a spectrum of fluted bands; increase it once more, and you will obtain a continuous spectrum. The scientific evidence for the statements I have made is unimpeachable. In the first place, I may examine spectra of bodies which I know to be compound. Special precautions often are necessary to accomplish this purpose, for too high a temperature would invariably break up the compound molecule into its more elementary constituents. For some bodies I may employ the low temperature of an ordinary Bunsen burner. With others, a weak electric spark taken from their liquid solutions will supply a sufficient quantity of luminous undecomposed matter to allow the light to be analyzed by a spectroscope of good power. The spectrum of a compound body is never a line-spectrum. It is either a spectrum of bands or a continuous spectrum. The spectra of the oxides, chlorides, bromides, or iodides of the alkaline earths, for instance, are spectra of fluted bands. All these bodies are known to contain atoms of different kinds—the metallic atoms of calcium, barium, or strontium, and the atoms of chlorine, bromine, iodine, or oxygen.

But to obtain these spectra of bands we need not necessarily have recourse to molecules containing different kinds of atoms. Elementary bodies show these spectra, and we must conclude therefore that the dissimilarity of the atoms in the molecule has nothing to do with the appearance of the fluted bands. Similarity in the spectrum must necessarily be due to a similarity in the forces which bind the atoms together, and this at once suggests that it is the compound nature of the molecule which is the true cause of the bands, but that the molecule need not be necessarily a compound of an atom with an atom of different kind, for it may be a compound of an element with itself. We have ample proof that this is the true explanation of the different types of spectra. I shall presently give you a few examples in support of the view which is now nearly unanimously adopted by spectroscopists.

I have hitherto left unmentioned one important method of investigating the periods of molecular vibrations, a method which is applica-

ble to low temperatures. If I have a transparent body and allow light sent out by a body giving a continuous spectrum to fall through it, I often observe that the transparent body sifts out of the light falling through it certain kind of rays. Spectra are thus produced which are called absorption spectra, because the body which is under examination does not send out any light, but absorbs some vibrations which are made to pass through it. It is an important fact that a molecule absorbs just the rays which it is capable itself of sending out. I can therefore investigate the spectrum of a body just as well by means of the absorption it produces as by means of the light which it sends out.

Vapors like bromine or iodine examined in this way give us a spectrum of fluted bands. A powerful spark in these gases gives, however, a line-spectrum. Here, then, a change of spectrum has taken place. The same body at different temperatures gives us a different spectrum, and the change which takes place is the same as that observed in the spectrum of a compound body the moment the temperature has risen sufficiently to decompose that body. I conclude from spectroscopic observations, therefore, that the molecules of bromine and iodine just above their boiling-point are complex molecules, which are broken up at the temperature of the electric spark. At high temperatures the molecules of these bodies contain a smaller number of atoms, and it follows from this that the gases must be lighter or that their density must be smaller. These conclusions, which on spectroscopic grounds have been definite and clear for some years, have recently, by independent methods, been confirmed by Victor Meyer and others. It has been directly proved that at high temperatures the molecules of iodine and bromine contain a smaller number of atoms than they do just above their boiling-point. In other cases the change of density has not been directly proved, only because these necessary measurements are difficult or even impossible at very high temperatures, but we may be perfectly sure that chlorine, as well as the metallic vapors of silver, sodium, potassium, etc., which show an analogous change of their spectra, will ultimately be proved to undergo a change of density at high temperatures.

As we can trace the change from a line-spectrum to a band-spectrum taking place simultaneously with an increase of density, so may we follow the change from a band-spectrum to a continuous spectrum indicating the formation of a molecule still more complex.

Sulphur-vapor, at a temperature just above its boiling-point, contains three times the number of atoms in one molecule that it does at a temperature of 1,000° Centigrade. The spectrum of sulphur-vapor observed by absorption is continuous when the heavier molecule only is present. At the higher temperatures, when each molecule is decomposed into three, the spectrum belongs to the type of fluted band-spectra. From the cases in which we can thus prove the change in the spectra and in the densities to go on simultaneously, we are justi-

fied in concluding that also in other cases, where no such change of density has yet been observed, it yet takes place; and it is not a very daring generalization to believe that a change in spectra is always due to a change in molecular arrangement, and generally, perhaps always, accompanied by a change in the number of atoms which are bound together into one molecule.

With regard to the well-known statement that solids and liquids give continuous spectra, while gases give line-spectra, it must be remarked that metallic vapors show in nearly all cases a continuous spectrum before they condense. Oxygen gives a continuous spectrum at the lowest temperature at which it is luminous. Examining liquids and solids by the method of absorption, we find that many of them show discontinuous spectra, presenting fairly narrow bands. It is not denied that the nearness of molecules does not affect the spectrum. It may render the bands more wide and indistinct at their edges, but its influence is more of a nature which in gas spectra is sometimes observed at high pressures when the lines widen, and does not consist of an alteration in type. Though in a solid or liquid body the molecules are much nearer together, they are less mobile; and hence the number of actual collisions need not be necessarily much increased. The fact that a crystal may show a difference in the absorption spectrum according as the vibrations of the transmitted light take place along or across the axis, shows, I think, that mutual impacts can not much affect the vibrations, but that each molecule, at least in a crystal, must be kept pretty well in its place.

We have divided spectra into three types, but in all attempts at classification we are met by the same difficulty. The boundaries between the different types are not in all cases very well marked. Every one will be able to distinguish a well-defined band-spectrum from a line-spectrum, but there are spectra taking up intermediate positions both between the line- and band-spectra and between band-spectra and continuous spectra. With regard to these it may be difficult to tell to which type the spectrum really belongs. It may happen that a change of spectrum takes place, the spectrum retaining its type; but in these cases, as a rule, the more complex molecule will have a spectrum approaching the lower type, although it may not actually belong to that lower type. To be perfectly general, we may say that a combination of atoms always produces an alteration in the spectrum in the direction of the change from the line-spectrum, through the band-spectrum to the discontinuous spectrum.

If we accept the now generally received opinion as to the cause of the different types of spectra, we may obtain information on molecular arrangement and complexity where our ordinary methods fail. At high temperatures, or under much diminished pressure, measures of density become difficult or impossible; and it is just in these cases that the spectroscope furnishes us with the most valuable information.

If we find three spectra of nitrogen and the same number for oxygen, we must accept the verdict, and conclude that these gases can exist in three different allotropic states.

Among the remarkable phenomena observed in vacuum-tubes, perhaps not the least curious is the spectrum observed at the negative pole, which in several cases is only observed there, and under ordinary circumstances in no other part of the tube. Both oxygen and nitrogen have a spectrum which is generally confined to the negative glow. Some years ago I tried to prove that also in these cases we have only to deal with a special modification of the gases which, curiously enough, only exists near the negative pole, and is broken up and decomposed in every other part of the tube. The experiments I then made seem to me to prove the point conclusively. After a current of electricity had passed through the tube for some time in one direction, the current was suddenly reversed; the negative pole now became positive, but the spectrum still was visible for some time in its neighborhood, and only gradually disappeared. This experiment shows that the spectrum may exist in other parts of the tube, and that it is therefore due to a peculiar kind of molecule, and not to anything specially related to electric phenomena taking place in the neighborhood of the negative pole. Other experiments supported this view.

The classification of spectra, according to the complexity of the vibrating molecule, is of great theoretical importance; for by its means we may hope to obtain some information on the nature of the forces which bind together the atoms into one molecule. Our whole life is a chemical process, and a great part of the mysteries of Nature would be cleared up if we could gain a deeper insight into the nature of chemical forces. I believe no other line of investigation to be as hopeful in this respect as the one which examines directly the vibrations of the molecules which take place under the influence of these chemical forces. If we could find a connection between the vibrations of a compound molecule and the vibrations of the simpler elements which it contains, we should have made a very decided step in the desired direction. I need not say that various attempts have been made to clear up so important a point; but we have to deal with complicated forces, and the attempts have as a rule not been crowned with much success.

There are, however, a few exceptions, a few cases of greater simplicity than the rest, where we are able to trace to their mechanical causes the spectroscopic changes which take place on chemical combination. These few and simple cases may serve as the finger-posts which show us the way to further research, and, we may hope, to further success. To make the spectroscopic changes of which I am speaking clear to you, I must have recourse to the analogy between sound and light, and remind you of the fact that when the prongs of a tuning-fork are weighted its tone is lowered, which means that the

period of vibration is increased, and consequently that the length of the wave of sound sent out is lengthened. Now, suppose a molecule or atom, the spectrum of which I am acquainted with, enters into combination with another; and suppose that the vibrations of the second molecule are weak, or lie outside the visible range of the spectrum: then the most simple assumption which I could make would be that the addition of the new molecule is equivalent to an increase of the mass of the other. An increase of mass without alteration of the force of the molecule will, as in the case of the tuning-fork, lengthen the period of vibration, and increase the wave-length. If a case of that kind were actually to happen, I should observe the whole spectrum shifting toward the red; and this is what is observed in the few simple cases to which I have referred. The first observation to that effect is due to Professor Bunsen, of Heidelberg. Examining the absorption spectra of different didymium salts, he found such a close resemblance between them, that no difference could be detected with instruments of small powers; but with larger instruments it was found that the bands varied slightly in position, that in the chloride they were placed most toward the blue end of the spectrum, that when the sulphate was substituted for the chloride a slight shift toward the less refrangible end took place, and that a greater shift in the same direction occurred on examining the acetate. Prof. Bunsen remarks that the molecular weight of the acetate is larger than that of the sulphate, and that the molecule of the sulphate, again, is heavier than that of the chloride. He adds: "These differences in the absorption spectra of different didymium compounds can not, in our present complete state of ignorance of any general theory for the absorption of light in absorptive media, be connected with

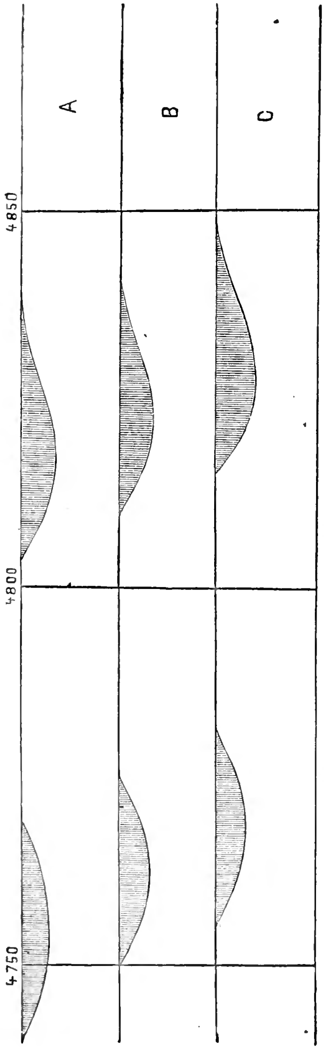


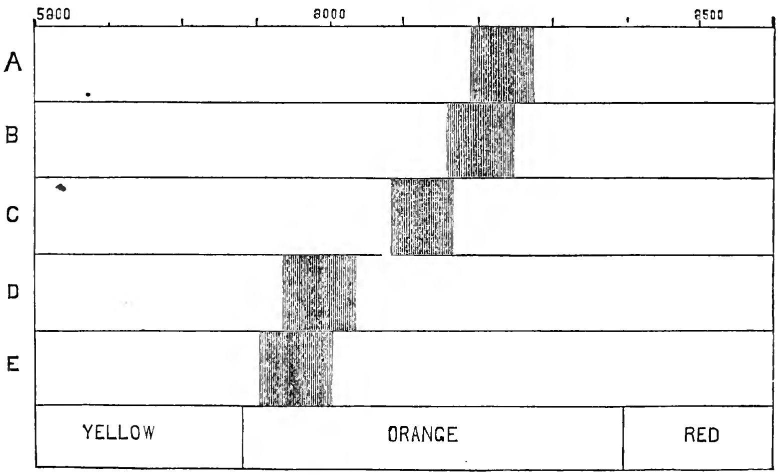
Fig. 1.

A = Absorption Bands in the Blue of Solution of Didymium Chloride.
B = " " " Sulphate.
C = " " " Acetate.

other phenomena. They remind one of the slight gradual alterations in pitch which the notes from a vibrating elastic rod undergo when the rod is weighted, or of the change of tone which an organ-pipe exhibits when the tube is lengthened." The accompanying woodcut (Fig. 1), copied from Professor Bunsen's paper, may serve to illustrate the shift observed in one of the absorption bands.

Similar changes take place when some substances like cyanin and chlorophyl are dissolved in different liquids. Absorption bands characteristic of these various substances appear, but they slightly vary in position. Professor Kundt, who has carefully examined this displacement of absorption bands, has come to the conclusion that as a rule the liquids of high dispersive powers were those which shifted the bands most toward the red end of the spectrum. But, though there is an apparent tendency in this direction, no rule can be given which shall be absolutely true whatever the substance which is dissolved. Fig. 2 shows the absorption spectrum of cyanin when dissolved in dif-

Fig. 2.



A = Absorption of Cyanin in Bisulphide of Carbon.
B = " " Nitrobenzene.
C = " " Benzene.
D = " " Ether.
E = " " Alcohol.

ferent liquids. The measurements made by Claes* are employed. We have here an interesting proof that a solution is sometimes much more of a chemical compound than is generally supposed. The solvent and the substance must, indeed, be closely connected in order to produce a shifting of the absorption band. On the other hand, it is not astonishing that no general law can be given which connects the displacement with the physical properties of the solvent, for the closeness of connection depending on the special chemical affinity for each

* "Wied. Annalen," iii, p. 388, 1878.

solvent has as much to do with the amount of shifting observed as the molecular weight or the dispersion or refractive power may have. The shifting of the absorption bands in different solutions of the same substances is only one of many applications of spectroscopes to the examination of molecular phenomena in liquids. Into the interesting researches of Professor Russell, who has greatly extended this field of inquiry, we have no time to enter.

The changes of spectra due to molecular combinations and rearrangements have in addition to their theoretical importance a great practical interest, for they will afford us some day a means of answering approximately a great many questions relating to the temperature of sun and stars. The gases and vapors in the solar atmosphere are for the greater part in the molecular condition in which they give a line-spectrum, and we know of stars the spectra of which resemble our solar spectrum very nearly. We shall not be far wrong in ascribing to such stars a temperature similar to that of our sun. Other stars have absorbing envelopes showing spectra of fluted bands. We know that fluted bands belong to a more complex molecular condition, which only can exist at lower temperatures. These stars, therefore, must have a lower temperature than our sun. Dr. Huggins, who has succeeded in obtaining most valuable photographs of star-spectra, has been able to classify and arrange star-spectra; and it is more than likely that, in the series of stars arranged in order by means of their spectra, we have at one end those of the highest, at the other those of the lowest, temperature. We are as yet far from being able to assign any particular temperature to a star, but the question by means of the spectroscope has been reduced to one which can be decided in our laboratories, and, however difficult it may be, we may rest assured that it will ultimately be solved. As to our sun, its temperature has been the subject of many investigations. Attempts have been made to deduce it (at least approximately) from the amount of heat it sends out. Different experimental laws have been proposed to connect together the heat radiation of a body, and the temperature of that body. The first law which was thus proposed gives 10,000,000° Centigrade as a lower limit; the second law reduces that lower limit to a little over 1,500°. Both these laws we now know to be wrong. More accurate laws give something like 10,000° or 20,000°, but the whole method employed is one which is open to a great many objections.

We measure the combined heat radiation of different layers on the solar surfaces, all of which are at different temperatures, and we observe only an average effect which is much influenced by the absorption in the outer layers of the solar atmosphere and in the corona, and does not admit of easy interpretation. The spectroscopic method, which is yet in its infancy, has the advantage that we can observe separately each layer of the sun; and we thus examine the temperature not as an average, but for every part of the solar body. Our way

to proceed would consist in carefully observing the spectra in different layers of the sun. Supposing we observe a change at one point, we may investigate at what temperature that change takes place, and we may then ascribe the same temperature to that particular place at the solar surface, if no other cause has interfered which may have affected our result. This last conditional limitation leads us to the discussion of the important but difficult question, whether we can determine any such interfering cause, which, not being temperature, yet produces the same change in a spectrum which we have hitherto only ascribed to changes of temperature.

I must here remark that a change in type is not the only spectroscopic change in the spectrum which is observed to take place on varying the temperature. Line-spectra especially are subject to curious variations in the relative intensities of their lines. These variations follow no general rule, and must be investigated separately for each element. The cause of this variation is a subject on which there exists a great difference of opinion; but, whatever this cause may be, if the changes always take place at one fixed temperature, we can turn them into account in measuring that temperature. However strong our wish that such a spectroscopic measurement of temperature may ultimately be obtained, a remarkable complication of facts has delayed the realization of this hope for at least a considerable period of time.

We have to enter partly into a theoretical question, and I must necessarily allude to some of the facts recognized by all who believe in the molecular theory of gases. Each molecule, which, as we have seen, sends out rays of light and heat on account of its internal motion, is surrounded by other molecules. These are, indeed, very closely packed, and continually moving about with enormous velocities. Generally they move in straight lines, but it must necessarily happen that often they come very near, and then affect and deflect each other. Perhaps they come into actual contact, perhaps they repel each other so strongly when near, that contact never takes place. The time elapsing between two such collisions is very small. If you can imagine one second of time to be magnified to the length of a hundred years, it would only take about a second, on the average, from the time a molecule has encountered one other molecule until it encounters the second. During the greatest part of this very short time, it moves in a straight line, for the forces between molecules are so small that they do not affect each other unless their distance is exceedingly small. It is, therefore, only during a very small fraction of time that one molecule is under the influence of another, and it is one of the greatest problems of molecular physics to find out what happens during that short element of time. I should like to explain to you how I believe the spectroscope may contribute its share to the settlement of that question. In his first great paper on the molecular theory of gases, the late Professor Clerk Maxwell assumed that two molecules may

actually come into contact, that they may strike each other, as two billiard-balls do, and then separate, according to the laws of elastic bodies. This theory is difficult of application when a molecule contains more than one atom, and, especially as it did not in the case of conduction of heat give results ratified by the experimental test, Maxwell abandoned it in favor of the idea that molecules repel each other according to the inverse fifth power of the distance. This second theory not only gave what at the time was believed to be the correct law for the dependence of the coefficient of conduction on temperature, but it also helped its author over a considerable mathematical difficulty. Further experiments have shaken our faith in the first of these two reasons, and the second is not sufficient to induce us to adopt without further inquiry the new law of action between two molecules.

It is exceedingly likely that the forces acting between two molecules when they are in close proximity to each other are partly due to, or at least modified by, the vibrations of the molecules themselves. Such vibrations must, as in the case of sound, produce attractive and repulsive forces, and vibrating molecules will affect each other in a similar way as two tuning-forks would. Now, if the forces due to vibrations play any important part in a molecular encounter, the spectroscope will, I fancy, give us some information. If two molecules of the same kind encounter, the periods of vibration are the same, and the forces due to vibration will remain the same during, perhaps, the whole encounter. If two dissimilar molecules encounter, the relative phase of the vibrations, and hence the forces, will constantly change. Attraction will rapidly follow repulsion, and the whole average effect will be much smaller than in the case of two atoms of the same kind. We have no clear notion how such differences may act, and we must have recourse to experiment to decide whether any change in the effect of an encounter is observed when a molecule of a different kind is substituted for a molecule having the same periods of vibration.

When a body loses energy by radiation, that energy is restored during an encounter; the way in which this energy is restored will profoundly affect the vibrations of the molecule, and hence the observed spectrum. I have endeavored by means of theoretical considerations, or speculations, as you may perhaps feel inclined to call them, to lead you on to an experimental law which I believe to be of very great importance. The spectrum of a molecule is in fact variable at any given temperature, and changes if the molecule is surrounded by others of different nature.

Placing a molecule in an atmosphere of different nature without change of temperature produces the same effect as would be observed on lowering of temperature.

Let me give you one example. Lithium at the temperature of the Bunsen flame has almost exclusively one red line in its spectrum. At the high temperature of the arc or spark the red line becomes weak,

and almost entirely disappears. It is replaced by a strong orange line, which is already slightly visible, though weak, at low temperatures, and by additional green and blue lines.

But even at the high temperature of the spark we may obtain again a spectrum containing the red line only if we mix a small quantity of lithium with a large quantity of other material. The same spark, for instance, will give us the low-temperature spectrum of lithium when taken from a dilute solution of a lithium salt, and the high-temperature spectrum when that solution is concentrated.

The spectra of zinc and tin furnish us other examples in the same direction, but the spectra of nearly all bodies show the same law in a more or less striking way.

If this law which I have given you is a true one,* and I believe it will stand any test to which no doubt it will be subjected, we shall be able to draw some important conclusions from it. In the first place, it will be proved that the forces between atoms do depend on their vibrations. If this is true, any change in the vibrations of the spectrum, however small, will entail a corresponding change in all the other properties of the body. On the other hand, any change in the affinities of the element observed by other means will be represented by a change in the spectrum.

It is also possible that the introduction of forces due to vibratory motion will help us over a considerable difficulty in the molecular theory of gases. Some of the conclusions of that theory are at present absolutely contrary to fact. A spectroscopist, for instance, who is acquainted with the mercury spectrum and all the changes in that spectrum which can take place, feels more than skeptical when he is told that the molecule of mercury contains only one atom, which neither rotates nor vibrates.

Nor can it be of advantage to science to pass silently over this difficulty, or to neglect it as unessential, as is often done by modern writers. The late Professor Maxwell, at least, was well aware of its importance, and has often expressed in private conversation how serious a check he considered the molecular theory of gases to have received. This is not the place to enter more fully into this point, and to consider how the vibratory forces may affect some of the suppositions on which the theoretical consequences are founded.

However important the effects of concentration or dilution on the

* Lockyer, "Studies in Spectrum Analysis," p. 140, draws attention to the fact that an admixture of a second element dims the spectrum of the first, and he expresses this fact by saying, "In encounters of dissimilar molecules the vibrations of each are damped." Later he has shown that the lines of oxygen and nitrogen, which are wide at atmospheric pressure, thin out when the gases are only present in small quantities. Lecoq de Boisbaudran in his "Atlas" gives several examples of the differences in the relative brilliancy of lines produced by concentrating or diluting the solution from which the spark is taken. The complete parallelism of this change to the changes produced by increased temperature has, however, never received sufficient attention.

spectra may be, they render the spectroscope less trustworthy as a thermometric instrument; for, if the company in which a molecule is placed changes the spectrum in the same way as temperature would, it will be difficult to interpret our results. But, although the discussion of our observations may be rendered more arduous and complicated, we need not on that account despair. It is one of the problems of spectroscopy to find out the composition of bodies, not only qualitatively, but also quantitatively, and, when we shall know in what proportion different bodies are distributed in the sun, we may reduce the problem of finding out this temperature to the much simpler one of finding out the temperature of a given electric spark.

I hope that the few facts which I have been able to bring before you to-night have given you some idea of the important questions which have been brought under the range of spectroscopic research. Many of these questions still await an answer, some have only been brought into the preliminary stage of speculative discussion, but the questions have been raised, and the student of the history of science knows that this is an important step in its development and progress. The spectrum of a molecule is the language which that molecule speaks to us. This language we are endeavoring to understand. The inexperienced in a new tongue which he is trying to learn does not distinguish small differences of intonation or expression. The power over these is only gradually and slowly acquired. So it is in our science. We have passed by, and no doubt still are passing by, unnoticed differences which appear slight and unimportant, but which when properly understood will give us more information than the rough and crude distinctions which have struck us at first. We have extended our methods of research; we have extended our power over the physical agents; we can work with the temperature of sun and stars almost as we can with those in our laboratories. No one can foretell the result, and perhaps in twenty years time another lecturer will speak to you of a spectroscopy still more modern in which some questions will have received their definite answer, and by which new roads will have been opened to a further extension of science.

ORIGIN AND HISTORY OF LIFE INSURANCE.

By THEODORE WEHLE.

LIFE insurance is based upon the theory that there is a law of mortality governing life; that is to say, that at all ages from birth to the utmost limits of life a certain proportion of individuals will die during fixed periods. Not that the precise duration of an individual life can be predicted, but that the ratio of deaths out of large aggre-

gates will remain the same under similar conditions. This conception, so self-evident to-day, was slow to dawn upon the human mind. Ancient pagan belief, various forms of superstition, as well as theology, all assumed life to be under the special control of a mysterious and arbitrary power. The conviction that it is subject to laws, as unalterable as those that govern the physical universe, has only gained ground within a comparatively recent period. Nor could such a view assert itself until mathematics and statistics had reached a certain degree of perfection ; for, previous to that, the law of averages and probabilities, as applicable to social problems, could not be understood.

Even after science had taken the initiative, and formulated the law upon such data as were accessible, a long period elapsed before steps were taken to apply its principles to practical ends. The conditions of society were as yet too unsettled, property and life too insecure, to permit such experiments. Not until after the middle of the eighteenth century did the desire to provide for widows, orphans, and other dependents, become so general as to lead to the establishment of a life-insurance society in London.

Since then the system has been steadily perfected, and has grown to considerable dimensions all over the civilized world. At present more than 600,000 lives are insured in the United States alone ; and the usefulness of the institution is only beginning to be properly appreciated. In view of this fact, and of the general interest that co-operative enterprises are attracting just now, it may be well to point out that life insurance must be reckoned among the grandest and most successful efforts ever attempted in that direction. It has, moreover, a century's experience to attest the strictly scientific principles upon which it rests. Such an institution well deserves to be better and more generally understood ; but, however large the number directly interested, it is strange how few have correct notions about it. This is probably attributable to the character of the literature on the subject, which, addressed to specialists, employs many technical terms, or, intended for soliciting agents, contains mere platitudes. Thus the impression prevails that it is either too dry or veiled in too much mystery to deserve the attention of even the educated classes.

It will be the aim of these articles, while giving an outline of the origin and history of mortality-tables, the results attained, and an explanation of the practical working of the whole system, to present it in so plain and popular a manner as to be readily understood by every intelligent reader.

I. Origin and History.—Among the nations of antiquity, the Romans were the first to make an effort to arrive at a law of mortality. To this they were led indirectly by their highly developed system of jurisprudence. It became necessary at times to fix the value of life-estates, i. e., property owned during lifetime only, without the right of alienation or bequest, and to do so the probability of life had to be

estimated. It appears that the method in common use was about equivalent to assuming that all persons who attain the age of thirty would certainly live to the age of sixty, and then certainly die. This purely arbitrary assumption was probably accepted by jurists as the simple solution of a difficult problem.

A great improvement was introduced by the Prætorian Prefect Ulpianus, one of the most eminent of Roman jurists. He published a table of mortality, in which a distinction was made between the different ages, and the probable number of years of life for each given. The rate of mortality assumed for the middle ages approximates to that probably prevalent previous to the seventeenth century. Whether this table was based upon actual observation or was purely speculative is not settled; but, if its estimates were correct, the chances of life above sixty years were very poor indeed among the Romans. However, these early efforts do not seem to have exercised any influence toward a proper investigation of the subject, and, having been forgotten, they only possess a passing interest for us.

The real germs from which life insurance ultimately developed were life-annuities and tontine annuities. These latter derived their name from a Neapolitan adventurer, Tonti, who came to Paris in 1653, in the reign of Louis XIV. He formed associations based upon the agreement that members should pay a certain sum of money into a fund, which was to be managed by him or other founders. The interest on this capital was annually divided among the surviving members, and, as their number grew smaller, their income became larger from time to time, until eventually the last survivor enjoyed the whole annual proceeds, which often were considerable. An instance is given of a widow who died in France in 1726, at the age of ninety-six, as the last survivor of a tontine society, having an income of 79,000 francs; her husband had been a surgeon, and had paid 300 francs for her membership in the association.

Such schemes were naturally attractive, and spread rapidly over Europe. Various modifications were introduced, adapting them to changing circumstances. Even governments had recourse to them as a means of raising money, when credit was low. The English Government made a tontine loan in 1693, comprising 1,002 members, the last of whom died in 1783. The other, known as the Great English Tontine, was started in 1789 for £1,000,000, embracing about 3,500 lives.

Voluntary associations for specific purposes were also quite frequent. One of a later date, originating in this city, may be mentioned by way of illustration. The Tontine Association of New York, established in 1794 by prominent merchants, upon 203 shares, applied its fund of about $40,000 to the erection of a coffee-house at the corner of Wall and Water Streets. There was an agreement that, when the nominees (mostly young children of the originators) should be reduced

to seven, the association should come to an end. Accordingly, in 1870, the requisite number being reached, steps were taken to have the property (which was then valued at $200,000) divided.

The advantages the tontines seemed to offer made them very enticing. The larger the number of deaths a prospectus would promise, the greater the expected gain to the survivors. No reliable calculation or precise prediction of the mortality was necessary, since they were to be guided by the actual experience only. But the very ease with which they could be formed tended to make them deteriorate into little better than mere lottery schemes, used by designing men to plunder the credulous.*

At present the tontine principle does not enlist our sympathy, being too selfish for our times, but it probably answered a good purpose in its day. Life and property were insecure, the investment of small sums difficult, the usury laws stringent : how natural for men to look to immediate enjoyment, when provision for the future was surrounded by so many uncertainties!

Nor is it likely that Tonti was the real originator of the idea. There is reason to assume that similar customs had taken root in Italian cities long before his time. Probably the same conditions and needs of society also led to the practice of purchasing life-annuities. It seems to have been a favorite mode of raising money, among the flourishing towns of the Netherlands, since the early part of the sixteenth century. On the payment of a certain sum to the party granting the life-annuity, a fixed annual income could be secured during lifetime.

Two other methods of making loans were also known to these old communities, namely, terminable and perpetual annuities.

Terminable annuities are such as are redeemable after a fixed number of years, and bear interest until maturity. That is the usual mode of investing funds at present.

Perpetual annuities are those that bear interest for ever, while the principal never becomes payable. Many European governments have funded their debts upon that principle, the most noted being the French *rentes* and the English consols.

The people of the Netherlands, that so early displayed commercial and political activity, continued to grow in importance until, by the middle of the seventeenth century, they ranked among the foremost nations of Europe. The freedom they enjoyed fostered material prosperity and encouraged the arts and sciences. Their statesmen and officials were often men of the highest attainments.

* These tontine associations must not be confounded with the so-called tontine life-insurance policies issued by some companies at the present day. These latter have simply borrowed the name, while in other respects they are like ordinary life-insurance policies; only that, instead of having dividends declared annually, they are held back for fixed periods, say ten or fifteen years, and then distributed among the surviving members.

One of the greatest among these was Jan de Witt, Grand Pensionary of Holland and West Friesland, a disciple of Descartes, and author of a mathematical work of note.

About contemporary with him, the eminent French thinker, Pascal, had laid down the first principles of the doctrine of chances. The celebrated Christian Huygens enlarged upon these inquiries in a treatise written in Dutch. When, in 1671, the States-General applied to De Witt to elaborate the best plan for raising a loan, he was the first to apply the principles of the science to a practical subject. In a memorable report he states that, for reasons given, it is better to negotiate funds by life-annuities, which by their nature are terminable, than to resort to either perpetual or terminable annuities. He shows that it had long been the practice in Holland to grant life-annuities at double the rate of interest current. That is to say, if four per cent. was customary, a loan of one hundred florins would bring four florins per annum, while one hundred florins applied to the purchase of a life-annuity would yield an income of eight florins. He goes on to prove that the practice of making no distinction between the ages, the selling a life-annuity on the same terms to the young and the old, was based on a fallacy. He then applies the doctrine of chances to data, most likely deduced from former annuity experiences, and proceeds to construct a mortality-table. This table, though erroneous in many respects, is still the first application of mathematical principles to questions of this kind, and, as such, deserves the highest consideration.

The report was never acted upon, and was lost before De Witt's contemporaries had become acquainted with it.

Toward the end of the seventeenth century, the subject of calculating a table of mortality began to create interest in scientific circles in England; but the difficulty was, to obtain reliable statistics. A few registers had been kept since 1538, and by 1600 they had been introduced into probably one half the parishes of England. Unfortunately, only births or baptisms had been entered. During the plague, the government was induced to publish mortality bills, showing the number of deaths; but here, also, the ages were not stated. The Royal Society, finding no data at home, turned to the Continent of Europe.

The city of Breslau, in Silesia, had kept an exact register of births and deaths for some time, and reliable copies for the five years from 1687 to 1691 were obtained. These were intrusted to the Astronomer Royal, the celebrated Dr. Halley, renowned for having calculated the orbit of a comet, which has been named after him. He published a treatise, which appeared in the "Philosophical Transactions" in 1693, giving the following mortality-table, the first that had ever been constructed on exact scientific principles:

BRESLAU TABLE.

Age.	Living.	Age.	Living.	Age.	Living.	Age.	Living.	Age.	Living.
1	1,000	19	604	37	472	55	292	73	109
2	855	20	598	38	463	56	282	74	98
3	789	21	592	39	454	57	272	75	88
4	760	22	586	40	445	58	262	76	78
5	732	23	579	41	436	59	252	77	68
6	710	24	573	42	427	60	242	78	58
7	692	25	567	43	417	61	232	79	49
8	680	26	560	44	407	62	222	80	41
9	670	27	553	45	397	63	212	81	34
10	661	28	546	46	387	64	202	82	28
11	653	29	539	47	377	65	192	83	23
12	646	30	531	48	367	66	182	84	20
13	640	31	523	49	357	67	172	85	15
14	634	32	515	50	346	68	162	86	11
15	628	33	507	51	335	69	152	87	8
16	622	34	499	52	324	70	142	88	5
17	616	35	490	53	313	71	131	89	3
18	610	36	481	54	302	72	120	90	1

Considering the disadvantages under which he labored, it was a wonderful production. He had no record of the whole population, and only 6,193 births and 5,869 deaths of all ages from which to draw his deductions.

The form of the table has been substantially retained to the present day. It begins with 1,000 children, in the first year of life, of whom 145 die in the course of the year. At the beginning of the second year there are 855 living, of whom 66 die in the course of that year; and so the table continues until, at the age of 90, the last one of the original number will die. The probability of dying in any one year of life is readily ascertained. For instance, in the first year of life, 145 die out of 1,000. Therefore, the probability of dying is $\frac{145}{1000} = \cdot 145$. In the second year 66 die out of 855, which makes the probability $\frac{66}{855} = \cdot 077$. That is to say, according to Halley's table, $14\frac{1}{2}$ per cent. of all newly-born children will die in the first year of life, and about $7\frac{3}{4}$ per cent. in the second year. Another interesting deduction pointed out by him is what a modern actuary has called the equation of life. It will be observed that, out of 1,000 at age 1, 499 will survive at 34, which indicates that the chances of dying or living to age 34 are about equal for a child at birth. It may be applied to any other age. At 19 the table shows 604 living, while at 54 there are 302; therefore, a youth at 19 has, to age 54, an equal chance of living or dying.

Whether Halley's table is a correct exposition of the mortality of the time it is difficult to say, since his data may have been insufficient; but the reasoning on which it was based and the conclusions drawn were strictly scientific.

But, while Halley's treatise must have been highly appreciated by mathematicians, the public at large seemed to have remained ignorant

of its value. Life-annuities continued to be sold on mere conjecture. Even the English Government made no distinction between different ages in the early part of the eighteenth century. A child at ten years could obtain a life annuity of £100 for £714, while it was probably worth over £1,300 at that time.

It is not within the province of this article to trace in detail the progress made in the science of life contingencies. Nearly every mathematician of note contributed to the perfection of the theory, while it was left almost exclusively to England to apply it in practice.

Passing over minor writers, Thomas Simpson, a self-taught mathematician, a mind of great originality, next deserves notice. In 1742 he enlarged upon the theory of Halley, De Moivre, and others, and, deeming the Breslau table not applicable to English conditions, he compiled and computed a mortality-table from the London mortality bills from 1728 to 1737. For a number of years he published pamphlets and delivered lectures on the subject, attracting the attention of the public at large.

Shortly thereafter James Dodson, also a very able mathematician, employed Simpson's tables, and made many valuable additions and suggestions thereto. He contributed a number of able papers to the "Philosophical Transactions," and was the first to point out, in 1755, how mortality-tables might be applied to the calculation of life-insurance premiums.

Up to this time, it will be noticed, life insurance in the modern sense was unknown. Both tontines and annuities had the very opposite object in view, sacrificing the whole capital for an increased income during lifetime. The reasons that made tontines popular have been briefly touched upon. Similar causes applied to life-annuities; besides, they provided a convenient way of evading the usury laws, and were often resorted to for that purpose. It was impossible to discriminate what part of the high rate of interest paid was for the use of money, and what percentage was due to the chance of death.

But, while life insurance as a system is of recent date, the practice of effecting temporary insurance on lives had its origin with the rise of marine insurance, probably as early as the fourteenth century. It was no more, however, than a mere bet, not based upon any experience or estimate, and led to many immoral devices. On that ground it was declared unlawful, and prohibited in the Netherlands, Spain, and Italy, together with other wager contracts, as far back as the fourteenth and fifteenth centuries. In England, however, there was no restriction, and, in the eighteenth century, betting on the lives of prominent men was carried on regularly at Lloyd's and other coffee-houses in London.

The spirit of gambling, that set in with the South-Sea bubble in 1720, continued to ebb and flow until the statute against wager contracts was enacted in 1773. It gave rise to a large number of wild

insurance schemes, most of which were ridiculous, while many were intentional frauds. The failures that necessarily followed created distrust and retarded the efforts that were just beginning to be made to introduce legitimate life insurance.

But a new era had begun in the history of the English people. The cessation of internal strife, the settlement of fundamental, constitutional questions, the increase of material prosperity, the greater power and intelligence of the people, and the growth of large towns, particularly London, had completely changed the conditions of society as compared with previous centuries. Selfishness and brutality gradually yielded to more forethought and refined feeling; family ties grew warmer and more generous. Comforts were greater, life and property more secure, and everything tended to a more vivid desire in thoughtful men to provide for their families in the contingency of their own death. The feeling was most pronounced among the clergy and other professional classes, and associations began to form to accomplish that purpose. The conditions on which they were based were somewhat similar to those even now in vogue, with benevolent institutions having the same object in view. On the death of a member, his heirs would receive a certain contribution from the surviving members.

Such arrangements, when a mere subordinate feature of benevolent societies, may work well for a time, but they can not serve as substitutes for life-insurance companies. These can only be founded on scientific principles, and all other devices must be futile and short-lived, as a century's experience has amply shown. The difficulties to be encountered were clearly foreseen and explained by the mathematicians of the day, and their labors did not prove in vain. In 1761 a number of gentlemen petitioned Parliament for a charter for a life-insurance association. They met with opposition, on the ground that the undertaking was purely speculative, devoid of any merit, and sure to fail. The charter not being granted, they organized in 1765, as a mutual insurance company, under the title of "The Equitable Society."

They were the first to issue policies for life, for a fixed amount, and at premiums not merely conjectural. Still, for a number of years their progress was very slow. But the public mind was agitated on the subject, and many men of superior ability were absorbed by it. Most prominent among these was Dr. Price, an unsuccessful Unitarian preacher, who had contributed many excellent papers to the "Philosophical Transactions," and published treatises on annuity values. He was consulted by one of the many insurance societies then forming, all of which he found started on a basis sure to lead to ruin. As he expressed it, "All London seems to be entering societies of this sort," and he determined to examine the subject thoroughly. What appeared an easy task proved the arduous labor of many years. The London mortality bills could not serve as a proper basis for insurance

calculations. The large and fluctuating population of a city like London, with its extremes of social conditions, could not be deemed a fair exponent of the value of healthy lives of the whole country. Dr. Price set to work to collect data from which trustworthy tables might be computed. He constructed quite a number of them, among which, one based on thirty years' mortality of Norwich, and another on ten years' observation at Chester, attracted considerable notice. He also applied such French, Dutch, and Swedish statistics as were available. But most important of all, and the one on which his fame chiefly rests, was the Northampton table, taken from thirty years' mortality observations of the town of Northampton. At the time of its publication, Dr. Price's numerous works had become widely known and his reputation was well established. In 1780 the Equitable Society, which had commenced with Dodson's London tables, concluded to adopt the Northampton table, and Dr. Price became the Society's consulting actuary. The directors generally followed his suggestions, and within a year he made 20,000 computations for them. The Society, now basing the reserves on the Northampton table, which showed a lower rate of mortality than Dodson's, found the surplus to accumulate rapidly, and large and frequent dividend additions were made to the old policies. With the reduction of the premiums the business increased steadily, and numbers of new companies were started in competition, whose fate we need not follow. Life insurance had become a practical system, established on a scientific basis.

The directors of the Equitable Society were intelligent and enterprising but very careful men. They had selected the Northampton table, from the different new tables presented, because among these it showed the highest rate of mortality. It proved to be based on a peculiar error of reasoning. An enumeration of the whole population could not be obtained, and the parish registers only gave a record of the christenings and deaths. But the town contained great numbers of Baptists, who repudiate infant baptism; and Dr. Price overlooked the fact that births and christenings were not identical, and assumed a much higher proportion of deaths to births than had actually occurred. The Northampton table came into general use, however, and the English Government, that had adopted it as a basis for annuity values, lost about £2,000,000 before its inaccuracy was discovered.

The next step of importance was the publication of a new mortality table, known as the Carlisle table, by an eminent actuary, Mr. Joshua Milne, in 1816. It was deduced from data obtained from the town of Carlisle, a very healthy and prosperous place, growing both by immigration and natural increase. During the eight years from 1779 to 1787 the population had risen from 7,677 to 8,677 inhabitants, being just 1,000, and the deaths recorded were 1,840. While the number under observation was very small, the advantage of having enumerations of the whole population was considerable. For the first

time it was possible, not only to compare births and deaths, but also to determine their proportion to the living. With the exception of the very young and old ages, where the numbers had been too few to make it reliable, the excellence of the Carlisle table was so pronounced that it quickly superseded the Northampton table, and remained in use until within a very recent period. With its adoption, premiums were again lowered, and the business increased largely. It outgrew the experimental stage, and, until then confined to England, began to extend to the Continent of Europe.

THE INSUFFICIENT USE OF MILK.

By DYCE DUCKWORTH, M. D., F. R. C. P.

I DESIRE to call attention to the insufficient employment of milk as an ordinary article of diet in this country. It may seem hardly possible to maintain that such a complaint is rightly grounded. All classes of persons are supposed to use milk, to some amount, as a matter of course. And although adults are not supposed to take very much, save what they consume with tea and coffee, yet children are commonly credited with the consumption of a good deal, or, at all events, of a sufficiency, of this commodity.

In this communication I propose to show that this common belief is largely erroneous, and that persons of all classes, and of all ages, in England, consume too little milk. The consequences of this starvation I hold to be serious, and the remedy for it perhaps not far to seek. The subject may be best considered, first, as it affects the communities settled in cities and towns ; and, secondly, in relation to the peasantry and country population generally.

Is is not too much to say that a fitting supply of milk is at present too seldom secured even by families who can well afford to pay for it. The full value of milk as an article of diet is not yet sufficiently appreciated by people who ought to be aware of it. Many adults regard it mainly as food for children, and many believe that they can not digest it, and state that it "curdles on the stomach," and makes them "bilious." The ordinary milk-supply to many establishments is just sufficient to allow their tea and coffee to be colored with it. A very inadequate quantity is often given to children, and the quality of it is no better than that yielded by skimmed milk, with, possibly, more or less water added to it. And in such households as I am now referring to, there is often, curiously enough, a stinginess in respect to cream, or what is made to pass for it, which, paltry and niggardly as it is, contrasts ridiculously, and I will say vulgarly, with the more free expenditure not uncommonly assented to on bad sherry and worse claret.

Any one, who knows what is meant by a cup of good tea, knows also that a certain quantity of good cream is an essential ingredient in it. There is, then, an incongruity between the inadequate supply of milk and cream and the free use of wine in such households, and the consequence is a serious nutritional loss to all the members of it.

The question of expense, however, does come to be a consideration in many families who are consistently economical, yet, even here, I maintain that a false economy prevails, if milk be in any degree stinted to their young and growing members.

The poorer classes are greatly starved of milk in the towns. Many among them so seldom get good milk that they acquire gradually a complete distaste for what goes by the name. The same, too, is the case with tea and coffee. The miserable decoctions which, among the poor, pass for these precious beverages, are so far from what they might and should be, that these people are naturally led to the unwholesome substitutions of bad beer and worse gin. A cup of good tea or coffee, with abundant milk in it, is a very unwonted treat and novel experience to the poor. I find much difficulty in enjoining the use of milk among hospital out-patients (and I order nothing so freely), partly, because they are incredulous as to its value ; partly, because they can not get enough of it, and when obtained it is so inferior ; and also, because they either dislike it, or allege that it disagrees with them. A sickly laborer, for instance, accustomed to sundry pints of beer and "drops" of gin, is aghast at the recommendation to substitute for these a pint or two of milk. Milk is as nauseous for him as his physic, possibly more so.

Now, in the matter of taking milk, there are reasons why this repugnance is felt. We most of us take, and enjoy, that which we have been accustomed to get, and those who have been brought up largely on milk naturally regard it with liking. Thus, the hardy Scotsman or Irishman, who has been well nourished on buttermilk, can well appreciate good milk when it is forthcoming. The southern Englishman is a poor creature in this respect.

Again, milk is a food that should not be taken in copious draughts like beer, or other fluids, which differ from it chemically. If we consider the use of milk in infancy, the physiological ingestion, that is, of it, we find that the sucking babe imbibes little by little the natural food provided for it. Each small mouthful is secured by effort, and slowly presented to the gastric mucous surface for the primal digestive stages. It is thus regularly and gradually reduced to curd, and the stomach is not oppressed with a lump of half-coagulated milk. The same principle should be regarded in the case of the adult. Milk should be slowly taken in mouthfuls, at short intervals, and thus it is rightly dealt with by the gastric juice. If milk be taken after other food, it is almost sure to burden the stomach, and to cause discomfort and prolonged indigestion, and this, for the obvious reason that there

is insufficient digestive agency to dispose of it. And, the better the quality of the milk, the more severe the discomfort will be under these conditions.*

Milk is insufficiently used in making simple puddings of such farinaceous foods as rice, tapioca, and sago. Distaste for these is engendered very often, I believe, because the milk is stinted in making them, or poor, skimmed milk is used. Abundance of new milk should be employed, and more milk, or cream, should be added when they are taken. In Scottish households this matter is well understood, and a distinct pudding-plate, like a small soup-plate, is used for this course. The dry messes commonly served as milky puddings in England are exactly fitted to create disgust for what should be a most excellent and delicious part of a wholesome dinner for both children and adults.

I am of opinion that much mischief results from the use of condensed milk, called Swiss milk, for children. I think it has a poor nutritive value compared with fresh good milk, and it is simply foolish for people to employ it when they can procure the real article. At sea, or when such milk as can be had is of doubtful quality, there may be just cause for resorting to it, but it is as unwise to employ it when fresh milk is procurable as it is to use extract of beef when freshly-made beef-tea can be had. I am aware that some infants will only take condensed milk, and appear to thrive upon it, but I think it is not to be trusted to for the highest nutritional purposes, and it should be discarded as soon as possible. The value of milk for the aged is not appreciated as it should be. If old age is a second childhood, the food for such persons should be that adapted to feeble digestive powers and the edentulous condition.

Many invalids and feeble persons can be induced to take milk with rum in it. This is at times a valuable prescription, but I find that people resort to it without medical advice, and some make it practically a mere excuse for a pernicious form of dram-drinking.

Milk and eggs in the form of custard is of high value. Some invalids, it should be known, can take custard-pudding cold when they can not take it hot, and with salt in it instead of sugar.

To illustrate what should be considered a proper milk-supply for a family and household consisting of ten persons, adults and children, I may state that five quarts *per diem* is the least quantity that should be consumed for all purposes. Children of any age may very well take a quart a day. If this, or anything approaching this, were the rule, instead of the exception, rickets, in its manifold phases, would be completely banished from this country, and a much higher standard of health and robustness would unquestionably prevail.

* The addition of a little carbonate of soda or of lime-water will often enable milk to be better digested. It is sometimes well to eat a dry biscuit and sip the milk between the mouthfuls. For weakly children with whom milk disagrees, good cream, diluted with two or three parts of water, may be often substituted with advantage.

I pass, secondly, to consider the present inadequate supply of milk to the peasantry and country people generally. It is not commonly known that the English peasantry get, as a rule, and in many parts of the country, less milk than the population of the towns. The swine are really better off in many instances.

Buttermilk should be used, and proves most wholesome and nutritious. When the gentry in any neighborhood are supplied with milk, little remains for the poorer folks to buy, and much of what they get is either doled out, as a form of charity, from the dairies of the rich, and is already skimmed, or too little for their real wants and requirements remains available for purchase.

The results of this milk-starvation in the country are readily observed; the children suffer much from want of good milk, and, hardly less, many of the adults. Milk and meat are rare commodities among the peasantry who are not so situated as to secure supplies on the estates of their masters. The loss of meat can be far better borne than that of milk. A good supply of vegetables, with cheese and onions, will make up for loss of much animal food, especially if wholesome brown, or whole meal, bread be eaten. The fact that the best bread, as it is termed, is so largely used by the poor, has often been shown to be due to the erroneous belief that the whitest bread is more wholesome and "goes further" than that made from "seconds" flour. A diet of this "best" bread and a scanty allowance of skimmed milk is, in truth, a very poor and ill-nourishing one. The strange fact remains that pampered servants, and the lower orders generally, prefer this poor stuff because it is called the best, while their betters, who eat darker-colored, or whole-meal bread, have no influence whatever in setting them a better example. It must strike all trained observers that there is a great deal of anæmia among the poorer country-folks, even in the healthiest districts, and much of this I believe to be due to errors in diet, and some of it to insufficient use of milk.

It comes to this, therefore—a large increase in our milk-supply is absolutely called for. It seems certain that our farmers can no longer grow cereals so as to make them a source of profit, or to meet the wants of our population. America, Canada, and India can always meet our deficiencies. Our corn-fields are rapidly being laid down in permanent pasture, but the herds of grazing-cattle we were wont to see are gradually dwindling away. Cattle-plague and various murrains explain this lamentable fact. But are these henceforth to prevail to such an extent as to curtail our home-growth of beef and our milk production? I, for one, sincerely trust not, and I hope I am not too sanguine when I express the belief that the time is not far distant when, by a large, a very large, increase in our grazing-stocks, we may at least meet the crying want of a much better milk-supply for the whole country.—*The Practitioner.*

INTELLIGENCE OF ANTS.

By GEORGE J. ROMANES.

I HAVE frequently been much struck by the absence of information, even among professed naturalists and professed psychologists, concerning the intelligence of ants. The literature on the subject being scattered and diffused, it is not many persons who have either the leisure or the inclination to search it out for themselves. Most of us, therefore, either rest in a general hazy belief that ants are wonderfully intelligent animals, without knowing exactly in what ways and degrees the intelligent action of these animals is displayed; or else, having read Sir John Lubbock's investigations, we come to the general conclusion that ants are not really such very intelligent animals, after all, but, as was to have been expected from their small size and low position in the zoölogical scale, it only required some such methodical course of scientific investigation to show that previous ideas upon the subject were exaggerated, and that, when properly tested, ants are found to be rather stupid than otherwise. I have therefore thought it well to write a paper for this widely circulated review, in order to diffuse some precise information concerning the facts of this interesting branch of natural history.

Not having any observations of my own to communicate, I have no special right to be heard on this subject; but, as I have recently had occasion to read through the literature connected with it, I am able to render what I may call a filtered abstract of all the facts which have hitherto been observed by others. It is needful, however, to add that the filter has been necessarily a close one; if I had a large volume instead of a short paper as my containing vessel, the filtrate would still require to be a strongly condensed substance.

Powers of Special Sense.—Let us take first the sense of sight. Sir John Lubbock made a number of experiments on the influence of light colored by passing through various tints of stained glass, with the following results: 1. The ants which he observed greatly disliked the presence of light within their nests, "hurrying about in search of the darkest corners" when light was admitted. 2. Some colors were much more distasteful to them than others; for while under a slip of red glass there were on one occasion congregated 890 ants, under a green slip there were 544, under a yellow 495, and under a violet only 5. 3. The rays thus act on these ants in a graduated series, which corresponds with the order of their influence on a photographic plate. Experiments were therefore made to test the effect of the rays on either side of the visible spectrum, but with negative results. In considering these experiments, however, it is important to remember that other observers (especially Moggridge in Europe, and McCook in America) have

described other species of ants (genus *Atta*) as fond of light. It would be interesting for any one who has an opportunity to try whether ants of this genus do not show toward the rays of the spectrum a scale of preference the reverse of that which Sir John Lubbock described.

As regards hearing, Sir John found that sounds of various kinds do not produce any effect upon the insects, nor could he obtain any evidence of their emitting sounds, either audible or inaudible to human ears.

It has long been known that the sense of smell in ants is highly developed, and it appears to be the sense on which, like dogs, they mainly rely. Huber proved that they track one another's footsteps in finding their way to food, etc.; for he observed, on drawing his finger across the trail so as to obliterate the scent, that the ants became confused and ran about in various directions, till they again came upon the trail on the other side of the interrupted space. By many ingeniously devised experiments Lubbock has amply confirmed Huber's statements, and concludes that in finding treasure "they are guided in some cases by sight, while in others they track one another by scent"—depending, however, more upon scent than upon sight.

There can be little doubt that ants have a sense of taste, as they are so well able to distinguish sugary substances; and it is unquestionable that in their antennæ they possess highly elaborated organs of touch.

Sense of Direction.—It is certain that ants, in common with many other animals, possess some unaccountable sense of direction, whereby they are able to find their way independently of landmarks, etc. Sir John Lubbock tried a number of experiments in this connection, of which the following is perhaps the most conclusive: Between the nest and the food he placed a hat-box, in each of two opposite sides of which he bored a small hole, so that the ants, in passing from the nest to the food and back again, had to go in at one hole and out at the other. The box was fixed upon a pivot, where it could be easily rotated, and, when the ants had well learned their way to the food through the box, the latter was turned half round as soon as an ant had entered it; "but in every case the ant turned too, thus retaining her direction."

Sir John then placed in the stead of a hat-box a disk of white paper. When an ant was on the disk making toward the food, he gently drew the paper to the other side of the food, so that the ant was conveyed by the moving surface in the same direction as that in which she was going, but *beyond* the point to which she intended to go. Under these circumstances the ant did not turn round, but went on to the farther edge of the disk, "when she seemed a good deal surprised at finding where she was."

These results seem to indicate that the sense of direction is due to a process of registering all the changes of direction which may be

made during the out-going journey, and that this power of registration has reference only to *lateral* movements ; it has no reference to variations in the *velocity* of advance along the line in which the animal is progressing.

Powers of Communication.—Huber, Forel, Kirby and Spence, Dujardin, Burmeister, Franklin, and other observers have all expressed themselves as holding the opinion that ants are able to communicate information to one another by some system of language or signs. The facts, however, on which the opinion of these earlier observers rested, have not been stated with that degree of caution and detail which the acceptance of their opinion would require. But the more recent observations of Bates, Belt, Moggridge, Hague, Lincecum, McCook, and Lubbock, leave no doubt upon the subject. Two or three instances will be enough to select in order to prove the general fact. Hague, the geologist, kept upon his mantel-shelf a vase of flowers, and he noticed a file of small red ants on the wall above the shelf passing upward and downward between the latter and a small hole near the ceiling. The ants, whose object was to get at the flowers, were at first few ; but they increased in number during several successive days, until an unbroken succession was formed all the way down the wall. To get rid of the ants, Hague then tried frequently brushing them off the wall upon the floor in great numbers ; but the only result was that another train was formed to the flowers ascending from the floor. He, therefore, took more severe measures, and struck the end of his finger lightly upon the descending train near the flower-vase, so killing some and disabling others. "The effect of this was immediate and unexpected. As soon as those ants which were approaching arrived near to where their fellows lay dead and suffering, they turned and fled with all possible haste, and in half an hour the wall above the mantel-shelf was cleared of ants." The stream from below continued to ascend for an hour or two, the ants advancing "hesitatingly just to the edge of the shelf, when, extending their antennæ and stretching their necks, they seemed to peep cautiously over the edge until beholding their suffering companions, when they too turned, expressing by their behavior great excitement and terror." Both columns of ants thus entirely disappeared. For several days there was a complete absence of ants : then a few began to reappear ; "but, instead of visiting the vase which had been the scene of the disaster, they avoided it altogether," and made for another vessel containing flowers at the other end of the shelf. Hague here repeated the same experiment, with exactly the same result. After this for several days no ants reappeared ; and during the next three months it was only when fresh and particularly fragrant flowers were put into the vases that a few of the more daring ants ventured to straggle toward them. Hague concludes his letter to Mr. Darwin, in which these observations are contained, by saying :

To turn back these stragglers and keep them out of sight for a number of days, sometimes for a fortnight, it is sufficient to kill one or two ants on the trail. . . . The moment the spot is reached an ant turns abruptly and makes for home, and in a little while there is not an ant visible on the wall.

Many other cases might be quoted to show that ants are able to communicate information to one another; but, to save space, I shall pass on to Sir John Lubbock's direct experiments upon this subject. Three similar and parallel tapes were stretched from an ant's nest to three similar glass vessels. In one of the latter Sir John placed several hundred larvæ, in another only two or three larvæ, and the third he left empty. The object of the empty glass was to see whether any ants might not run along the tapes without any special reference to the obtaining of larvæ; and this was found not to be the case. Sir John then put an ant to each of the other two glasses; they each took a larva, carried it to the nest, returned for another, and so on. Each time a larva was taken out of the glass containing only two or three, Sir John replaced it with another, so that the supply should not become exhausted. Lastly, every ant (except the two which had first been put to the larvæ), before reaching home with her burden, was caught and imprisoned till the observation terminated.

The result was, that during forty-seven and a half hours the ants which had access to the glass containing numerous larvæ brought 257 friends to their assistance; while during an interval of five and a half hours longer those which visited the glass with only two or three larvæ brought only 82 friends. This result appears very conclusive as proving some power of definite communication, not only as to where food is to be found, but also as to the road which leads to the *largest store*. Further experiments, however, proved that these ants are not able to *describe the precise locality* where treasure is to be found. For, having exposed larvæ as before and placed an ant upon them, he watched every time that she came out of the nest with friends to assist her; but, instead of allowing her to pilot the way, he took her up and carried her to the larvæ, allowing her to return with a larva upon her own feet. Under these circumstances the friends, although evidently coming out with the intention of finding some treasure, were never able to find it, but wandered about in various directions for a while, and then returned to the nest. Thus, during two hours, she brought out altogether in her successive journeys no less than 120 ants, of which number only five in their unguided wanderings happened by chance to find the sought-for treasure.

Memory.—The general fact that, whenever an ant finds her way to a store of food or larvæ, she will return to it again and again in a more or less direct line from her nest, constitutes ample proof that the ant remembers her way to the store of food. It is of interest to note that the nature of this insect-memory appears to be identical with that of memory in general. Thus, a new fact becomes *impressed* upon ant-

memory by repetition, and the impression is liable to become effaced by lapse of time. Sir John Lubbock found it necessary to *teach* the insects, by a repetition of several lessons, their way to treasure, if that way were long or unusual. With regard to the *duration* of memory in ants, it does not appear that any direct experiments have been made ; but the following observation by Mr. Belt on its apparent duration in the leaf-cutting ant may be here stated : In June, 1859, he found his garden invaded by these ants, and on following up their paths he found their nest about a hundred yards distant. He poured down their burrows a pint of diluted carbolic acid. The marauding parties were at once drawn off from the garden to meet the danger at home, while in the burrows themselves the greatest confusion prevailed. Next day he found the ants busily engaged in bringing up the ant-food from the old burrows and carrying it to newly formed ones a few yards distant. These, however, turned out to be intended only as temporary repositories ; for in a few days both old and new burrows were entirely deserted, so that he supposed all the ants to have died. Subsequently, however, he found that they had migrated to a new site, about two hundred yards from the old one, and there established themselves in a new nest. Twelve months later the ants again invaded his garden, and again he treated them to a strong dose of carbolic acid. The ants, as on the previous occasion, were at once withdrawn from his garden, and two days afterward he found "all the survivors at work on one track that led directly to the old nest of the year before, where they were busily employed in making new excavations. . . . It was a wholesale and entire migration." Mr. Belt adds, "I do not doubt that some of the leading minds in this formicarium recollected the nest of the year before, and directed the migration to it." Of course, it is possible that the leaders of the migration may have simply stumbled on the old burrows by accident, and, finding them already prepared as a nest, forthwith proceeded to transfer the food and larvæ ; but, as the old and the new burrows were separated from one another by so considerable a distance, this supposition does not seem probable, and the only other one open is that the ants remembered their former home for a period of twelve months. This supposition is rendered the more probable from a somewhat analogous case recorded by Karl Vogt in his "Lectures on Useful and Harmless Animals." For several successive years ants from a certain nest used to go through certain inhabited streets to a chemist's shop six hundred metres distant, in order to obtain access to a vessel filled with sirup. As it can not be supposed that this vessel was found in successive working seasons by as many successive accidents, it can only be concluded that the ants remembered the sirup-store from season to season.

Recognition.—I shall now pass on to consider a class of highly remarkable facts. It has been known since the observations of Huber

that all the ants of the same community recognize one another as friends, while an ant introduced from another nest, even though it be an ant of the same species, is known at once to be a foreigner, and is usually maltreated or put to death. Huber found that, when he removed an ant from a nest and kept it away from its companions for a period of four months, it was still recognized as a friend, and caressed by its previous fellow-citizens after the manner in which ants show friendship, viz., by stroking antennæ. Sir John Lubbock, after repeating and fully confirming these observations, extended them as follows:

He first tried prolonging the period of separation beyond four months, and found that it might be made more than three times as long without the ants forgetting their absent friend. Thinking that this fact could only be explained, either by all the ants knowing each other's personal appearance, or by their all having a distinctive smell peculiar to each nest, or by their all having a sign, like a pass-word, differing in different nests, Sir John tried separating some ants from a nest while still in the condition of larvæ, and, when they emerged as perfect insects, transferring them back to the nest from which they had been taken as larvæ. Of course, in this case the ants in the nest could never have *seen* those which had been removed, for a larval ant is as unlike the mature insect as a caterpillar is unlike a butterfly; neither can it be supposed that the larvæ, thus kept away from the nest, should retain, when hatched out as perfect insects, any smell belonging to their parent nest; nor, lastly, is it reasonable to imagine that the animals, while still in the condition of larval grubs, can have been taught any gesture or sign used as a pass-word by the matured animals. Yet, although all these possible hypotheses seem to be thus fully excluded by the conditions of the experiment, the result showed unequivocally that the ants all recognized their transformed larvæ as native-born members of their community.

Next, therefore, Sir John Lubbock tried dividing a nest into two parts before the queen ants had become pregnant. Seven months after the division the queens laid their eggs, and five months later these eggs had developed into perfect insects. He then transferred some of these young ants from the division of the nest in which they had been born to the division in which they had never been, even in the state of the egg. Yet these ants also were received as friends, in marked contrast to the reception accorded to ants from any other nest. It therefore seems to be blood-relationship that ants are able, in some way that is as yet wholly inexplicable, to recognize. It ought, however, to be remembered in this connection that, in an experiment made by Forel on slave-making ants, it was proved that they almost instantaneously recognized their own slaves from other slaves of the same species—and this after their slaves had been kept away from the nest for a period of four months.

Under this heading I may also allude to the unquestionable evidence concerning enormous multitudes, or, as we might say, a whole nation of ants, all recognizing one another as belonging to the same nationality. No doubt the principle (whatever it may be) on which the power of recognition depends is the same here as it is in the case of a single nest; but, in the cases which I am about to quote, the operation of this principle is indefinitely and incalculably extended. The cases to which I allude are those in which new ants' nests spring up as off-shoots from the older ones, so that a nation of towns, as it were, gradually spreads to an immense circumference round an original center. Forel describes such a nation of *Formica exsecta* which comprised more than two hundred nests, and covered a space of nearly two hundred square metres. Individual ants must here have been numbered by the million, and yet they all knew each other as friends—even those taken from farthermost nests—while they would admit no foreigners within their territory.

A still more remarkable case is recorded by McCook of what he calls an "ant town." The one he has described occurs in the Alleghany Mountains of North America, and consists of sixteen or seventeen hundred nests, which rise in cones to a height of from two to five feet. The ground below is riddled in every direction with subterranean passages of communication. The inhabitants are all on the most friendly terms, so that if any one nest is injured it is repaired by help from the other nests. Here, also, foreign ants of the same species were not tolerated; so that we should have an analogous case if all the inhabitants of Europe should be directly known to one another as friends, while an American or an Australian, on setting foot upon European ground, should be immediately set upon as an enemy.

Emotions.—The pugnacity, valor, and rapacity of ants are too well and generally known to require the narration of special instances of their display. With regard to the tenderer emotions, however, there is among observers a difference of opinion. Sir John Lubbock found that the species of ants on which he experimented are apparently deficient in feelings both of affection and of sympathy. He tried burying some specimens of *Lasius niger* beneath an ant-road; but none of the ants traversing the road made any attempt to release their imprisoned companions. He repeated the same experiment, with the same result, on various other species. Even when the friends in difficulty were actually in sight, it by no means followed that their companions would assist them. On imprisoning some friends in one bottle, the mouth of which was covered with muslin, and some strangers of the same species (*F. fusca*) in another bottle similarly protected, and placing both bottles in the nests, "the ants which were at liberty took no notice of the bottle containing their imprisoned friends. The strangers in the other bottle, on the other hand, excited them considerably." For days they crowded round this bottle, endeavoring to

gnaw through the muslin by which its mouth was closed. This on the seventh day they succeeded in doing, when they killed the imprisoned strangers. "The friends throughout were quite neglected," so that this experiment, as Sir John observes, seems to show that "in these curious insects hatred is a stronger passion than affection." This experiment always gave the same result in the case of this species; but, when tried with *Formica rufescens*, the ants took no notice of either bottle, and showed no signs either of affection or hatred; so that, as Sir John again observes, "one is almost tempted to surmise that the spirit of these ants is broken by slavery"—i. e., by the habit of keeping slaves.

But there is no lack of evidence to show, *per contra*, that the tenderer emotions have a place in ant-psychology. Even the hard-hearted species which Sir John Lubbock observed grew sympathetic toward sick or injured friends. Thus he observed that a specimen of *F. fusca*, which was congenitally destitute of antennæ, and which had been attacked by an ant of another species, excited the sympathy of a friend on being placed near her own nest. This friend "examined the poor sufferer carefully, then picked her up tenderly, and carried her away into the nest. It would have been difficult for any one who witnessed this scene to have denied to this ant the possession of humane feelings." Again, Moggridge has seen one ant carry another sick and apparently dead ant "down the twig which formed their path to the surface of the water, and, after dipping it in for a minute, carry it laboriously up again, and lay it in the sun to dry and recover."

But some species of ants seem habitually to show affection and sympathy even toward healthy companions in distress. Thus Belt writes of the *Eciton humata*, that "one day watching a small column of these ants, I placed a little stone on one of them to secure it. The next that approached, as soon as it discovered its situation, ran backward in an agitated manner, and soon communicated the intelligence to the others. They rushed to the rescue," and by their concerted action effected the release of their companion. Similarly ants of this species which Belt buried were always dug out by their friends. To quote one such instance, the ant which first found the buried one

> tried to pull her out, but could not. It immediately set off at a great rate, and I thought it had deserted her comrade, but it had only gone for assistance; for in a short time about a dozen ants came hurrying up, evidently fully informed of the circumstances of the case, for they made directly for their imprisoned comrade and set him free. I do not see how this could be instinctive. It was sympathetic help, such as men only among the higher mammalia show. The excitement and ardor with which they carried on their unflagging exertions for the rescue of their comrade could not have been greater if they had been human beings.

Ford and McCook have also observed displays of sympathy and affection by other species.

Nursing.—This may appropriately be considered in connection with the emotions, as it seems to imply something akin to maternal affection. The eggs will not develop into larvæ unless nursed, and the nursing is effected by licking the surface of the eggs, which under the influence of this process increase in size, or grow. In about a fortnight—during which time the workers carry the eggs from higher to lower levels of the nest, and *vice versa*, according to the circumstances of heat, moisture, etc.—the larvæ are hatched out, and require no less careful nursing than the eggs. The workers feed them by placing mouths together—the larvæ stretching out their heads to receive the nourishment after the manner of young birds. When fully grown the larvæ spin cocoons, and are then pupæ, or the "ants' eggs" of the pheasant-rearers. These require no food, but still need incessant attention with reference to warmth, moisture, and cleanliness. When the time arrives for their emergence as perfect insects, the workers assist them to get out of their larval cases by biting through the walls of the latter. When it emerges, the newly-born ant is inclosed in a thin membrane like a shirt, which has to be pulled off. "When we see," says Büchner, "how neatly and gently this is done, and how the young creature is then washed, brushed, and fed, we are involuntarily reminded of the nursing of human babies." The young ants are then educated. They are led about the nest and taught their various domestic duties. Later on they learn to distinguish between friends and foes; and when an ant's nest is attacked by foreign ants the young ones never join in the fight, but confine themselves to removing the pupæ. That the knowledge of hereditary enemies is not wholly instinctive is proved by the experiment of Forel, who put young uneducated ants of three different species into a glass case with pupæ of six other species—all the nine species being naturally hostile to one another. Yet the young ants did not quarrel, but worked together to tend the pupæ. When the latter hatched out, an artificial colony was formed of a number of naturally hostile species, all living together like the "happy families" of the showmen.

Keeping Aphides.—It is well and generally known that various species of ants keep aphides, as men keep milch-cows, to supply a nutritious secretion. Huber first observed this fact, and noticed that the ants collected the eggs of the aphides, and treated them with as much apparent care as they treated their own. When these eggs hatch out, the aphides are usually kept and fed by the ants. Sometimes the stems and branches on which they live are incased by the ants in clay walls, in which doors are left large enough to admit the ants, but too small to allow the aphides to escape. The latter are therefore imprisoned in regular stables. The sweet secretion is yielded to the ants by a process of "milking," which consists in the ants stroking the aphides with their antennæ.

Sir John Lubbock has made an interesting addition to our knowl-

edge respecting the habit in question, as practiced by a certain species of ant (*Lasius flavus*), which departs in a somewhat remarkable manner from the habit as practiced by other species. He says: "When my eggs hatched I naturally thought that the aphides belonged to one of the species usually found on the roots of plants in the nests of *Lasius flavus*. To my surprise, however, the young creatures made the best of their way out of the nest, and, indeed, were sometimes brought out of the nest by the ants themselves." Subsequent observation showed that these aphides, born from eggs hatched in the ants' nest, left the nest, or were taken from it, as soon as they were hatched, in order to live upon a kind of daisy which grew around the nest. Sir John then made out the whole case to be as follows:

> Here are aphides, not living in the ants' nests, but outside, on the leaf-stalks of plants. The eggs are laid early in October on the food-plant of the insect. They are of no direct use to the ants, yet they are not left where they are laid, where they would be exposed to the severity of the weather, and to innumerable dangers, but are brought into their nests by the ants, and tended by them with the utmost care through the long winter months until the following March, when the young ones are brought out and again placed on the young shoots of the daisy. This seems to me a most remarkable case of prudence. Our ants may not perhaps lay up food for the winter, but they do more, for they keep during six months the eggs which will enable them to procure food during the following winter.

As a supplement to this interesting observation, I may here append the following, which is due to Herr Nottebohm, who communicated it to Professor Büchner: This gentleman had a weeping-ash which was covered by millions of aphides. To save the tree, he one day in March cleaned and washed every branch and spray before the buds had burst, so removing all the aphides. There was no sign of the latter till the beginning of June, when he was surprised one fine sunny morning to see a number of ants running quickly up and down the trunk of the tree, each carrying up a single aphis to deposit it on the leaves, when it hurried back to fetch another. "After some weeks the evil was as great as ever. . . . I had destroyed one colony, but the ants replanted it by bringing new colonists from distant trees and setting them on the young leaves."

Aphides are not the only insects which are utilized by ants as cows. Gall-insects and cocci are kept in just the same way; but McCook observed that, where aphides and cocci are kept by the same ants, they are kept in separate chambers, or stalls. Caterpillars of the genus *Lycæna* have also been observed to be kept by ants for the sake of a sweet secretion which they supply.

Slavery.—The habit or instinct of keeping slaves obtains at least among three species of ant. It was first observed by P. Huber in *Formica rufescens*, which enslaves the species *F. fusca*, the members of which are appropriately colored black. The slave-making ants

attack a nest of *F. fusca* in a body; there is a great fight with much slaughter, and, if victorious, the slave-makers carry off the pupæ of the vanquished nest in order to hatch them out as slaves. When these pupæ hatch out, the young slaves begin their life of work, and seem to regard their masters' home as their own, for they never attempt to escape, and they fight in defense of the nest should it be attacked. The work that devolves upon the slaves differs according to the species which has enslaved them. In the nests of *F. sanguinea* the comparatively few captives are kept exclusively as household slaves, all the out-door work of foraging, slave-capturing, etc., being performed by the masters; and when for any reason a nest has to migrate, the masters carry their slaves in their jaws. On the other hand, *F. rufescens* assigns a much larger share of work to the slaves, which they capture in much larger numbers to take it. In this species the masters do no work whatsoever, unless the capturing of slaves be regarded as such. Therefore the whole community is entirely dependent upon its slaves; the masters are not able to make their own nests, to feed their own larvæ, or even to feed themselves; they die of starvation in the midst of favorite food if a slave should not be present to hand it in proper form. In order to confirm this observation (originally due to Huber) Lespès placed a piece of moistened sugar near a nest of these slave-makers. It was soon found by one of the slaves, which gorged itself and returned. Other slaves then came out and did likewise. Some of the masters next came out, and by pulling the legs of the feeding slaves reminded them that they were neglecting their duty. The slaves then immediately began to serve their masters to the sugar. Had they not done so, there is no doubt they would have been punished, for the masters bite the slaves when displeased with them. Forel and Darwin have also confirmed these observations of Huber. Indeed, the structure of the mouth in *F. rufescens* is such as to render self-feeding difficult, if not physically impossible. Its long and narrow jaws, admirably adapted to pierce the head of an enemy, do not admit of being used for feeding unless liquid food is poured into them from the mouth of a slave.

Ants do not appear to be the only animals of which ants make slaves; for there is at least one case in which these wonderful insects enslave insects of another species, which may therefore be said to stand to them in the relation of beasts of burden. The case to which I allude stands upon the authority of Audubon, who says that he has seen certain leaf-bugs used as slaves by ants in the forests of Brazil.

> When these ants want to bring home the leaves which they have bitten off the trees, they do it by means of a column of these bugs, which go in pairs, kept in order on either side by accompanying ants. They compel stragglers to reënter the ranks, and laggards to keep up by biting them. After the work is done, the bugs are shut up within the colony and scantily fed.

WARS.—On the wars of ants a great deal might be said, as the facts of interest in this connection are very numerous; but for the sake of brevity I shall confine myself to giving only a somewhat meager account. One great cause of war is the plundering of ants' nests by the slave-making species. Observers all agree that, in the case of the so-called Amazon slave-making ant, this plundering is effected by a united march of the whole army composing a nest, directed against some particular nest of the species which they enslave. According to Lespès and Forel, single scouts or small companies are first sent out from the nest to explore in various directions for a suitable nest to attack. These scouts afterward serve as guides to the marauding excursion. When the scouts have been successful in discerning a suitable nest to plunder, and have completed their strategical investigations of the locality to their satisfaction—the latter process being often a laborious one, as it has special reference to the entrances of the nest, which are purposely made difficult to find by their architects—they return to their own fortress. Forel has seen them then walk about on the surface of this underground fortress for a long time, as if in consultation, after which some of them entered and again came out leading the host of warriors; these streamed from all the gateways, and ran about tapping each other with their heads and antennæ. They then formed into a column, composed of between one and two thousand individuals, and set out in orderly march to pillage the nest which had been examined by the scouts. According to Lespès, the column is about five metres long and fifty centimetres wide, marches at the rate of a metre per minute, and, on account of the distance which may have to be traversed, the march sometimes lasts for more than an hour. When they arrive at their destination a fierce battle begins, which, after raging for a time with much slaughter on both sides, generally, though not invariably, ends in the robbers gaining an entry. A barricade conflict then takes place below-ground, and, if the attack proves successful, the slave-making ants again stream out of the plundered nest, each ant carrying a stolen pupa. The Amazons can not climb, and this fact being known to the other ants, when they find that victory is on the side of the enemy, they devote themselves to saving what treasure they can by carrying their pupæ up the grasses and bushes surrounding the nest. When the marauders have obtained all the booty that they can, they set off on their homeward march, each carrying a pupa. They do not always follow the shortest road, but return exactly on the track by which they came, no doubt being guided entirely by the scent left on the ground from their previous march. When they arrive home they commit the pupæ to the care of the slaves. Forel found that a particular colony of slave-makers watched by him sent out forty-four marauding expeditions in thirty days, of which number twenty-eight were completely successful, nine partially so, and the remainder failures. The average booty obtained by a successful expedition was one thou-

sand pupæ, so that during a single summer the total number of pupæ captured by this colony might be put down at forty thousand.

Forel further tried the following experiment: He kept nests of two species of slave-making ants in two separate sacks, and when he saw that an expedition of a third species (Amazons) had found a slave-nest to plunder, and were fairly on their march toward it, he turned out one of his sacks upon the nest. A fight at once began between the slave-ants and sanguine ants which he had turned loose upon them. Then the vanguard of the Amazons came up; but, when they saw that the sanguines were already on the field, they drew back and awaited the approach of the main army. In close order this whole army then precipitated itself upon the already struggling host of sanguine ants. The latter, however, repulsed the attack, and the Amazons retired to reform. This done they made a second assault, which appearing as if it would end successfully, Forel, to complicate matters, poured upon the field his second sack containing the third species of slave-makers. All three species then fought together, till at last victory declared itself on the side of the Amazons. After overcoming their enemies they paused for a breathing-space before beginning the work of plunder. They then ravished the nest of the slave-ants, which, however, fought desperately, so that it seemed as though they courted death. They even followed the Amazons right up to their own nest, harassing them all the way. On arriving at the nest of the Amazons the slaves of the latter came out and assisted their masters to fight. These slaves were of two species—one being the same as that which was being plundered, so that these slaves were fighting for their masters against their own kind. Altogether, therefore, in that day's warfare there were six different species of ants engaged—three in alliance, and the rest in mutual antagonism.

The military tactics employed by the sanguine ants above mentioned are different from those employed by the Amazons. They do not seek to carry the fortress of the slave-ants by storm, but lay a regular siege, forming a complete circle round the nest, and facing it with jaws held fiercely open and antennæ thrown back. Being individually large and strong, they are able thus to confine the whole nest of slave-ants. A special guard is set upon the entrances of the nest, and this allows all slave-ants not carrying pupæ to pass, while it stops all the slave-ants which carry pupæ. The siege lasts till most of the slave-ants have thus been allowed to pass out, while all the pupæ are left behind. The forces then close in upon the entrances and completely rifle the nest of its pupæ—a few companies, however, being told off to pursue any slave-ants which may possibly have succeeded here and there in escaping with a pupa.

Wars are not confined to species of ants having slave-making habits. The agricultural ants likewise at times have fierce contests with one another. The importance of seeds to these insects, and the

consequent value which they set upon them, induce the animals, when supplies are scarce, to plunder one another's nests, prolonged warfare being the result. Thus Moggridge says: "By far the most savage and prolonged contests which I have witnessed were those in which the combatants belonged to two different colonies of the same species. . . . The most singular contests are those which are waged for seeds by *A. barbara*, when one colony plunders the stores of an adjacent nest belonging to the same species; the weaker nest making prolonged, though, for the most part, inefficient attempts to recover their property." In one case the predatory war lasted for forty-six days, during which time it became evident that the attacking nest was the stronger, for

> streams of ants laden with seeds arrived safely at the upper nest, while close observation showed that very few seeds were successfully carried on the reverse journey into the lower or plundered nest. Thus, when I fixed my attention on one of these robbed ants surreptitiously making its exit with the seed from the thieves' nest, and having overcome the oppositions and dangers met with on its way, reaching, after a journey which took six minutes to accomplish, the entrance to its own home, I saw that it was violently deprived of its burden by a guard of ants stationed there apparently for the purpose, one of whom instantly started off and carried the seed all the way back again to the upper nest. . . . After the 4th of March I never saw any acts of hostility between these nests, though the robbed nest was not abandoned. In another case of the same kind, however, where the struggle lasted thirty-two days, the robbed nest was at length completely abandoned.

Lastly, McCook records the history of an interesting engagement which he witnessed between two nests of *Tetramorium cæspitum* in the streets of Philadelphia, and which lasted for nearly three weeks. Although all the combatants belonged to the same species, friends were always distinguished from foes, however great the confusion of the fight. This fact is always observable in the case of battles between nests of the same species, and McCook thinks that the distinction appears to be effected in some way by contact of antennæ.

Keeping Pets.—Many species of ants display the curious habit of harboring in their nests sundry kinds of other insects, which, so far as observation extends, are of no benefit to the ants, and which have therefore been regarded by observers as mere domestic pets. These pets are, for the most part, species which occur nowhere else except in ants' nests, and each species of pet is peculiar to certain species of ant. Beetles and crickets seem to be the more favorite kinds of insects, and these live on the best terms with their hosts, playing round the nests in fine weather, and retiring into them in stormy weather, while allowing the ants to carry them from place to place during migrations. It is evident, therefore, that ants not only tolerate these insects, but foster them; and, as it seems absurd to credit the ants with any mere fancy or caprice, such as that of keeping pets, it is per-

haps safest to suppose that these insects, like the aphides, are of some use to their masters, although we are not yet in a position to surmise what this use can be.

Sleep and Cleanliness.—It is probable that all ants enjoy periods of true slumber alternating with those of activity; but actual observations on this subject have only been made in the case of two or three species. McCook says that the harvesting ants of Texas sleep so soundly that they may be pretty severely stroked with a feather without being aroused; but they are immediately awakened by a sharp tap. On awakening they often stretch their limbs in a manner precisely resembling that of warm-blooded animals, and even yawn—the latter action being "very like that of the human animal; the mandibles are thrown open with the peculiar muscular strain which is familiar to all readers; the tongue is also sometimes thrust out." The ordinary duration of sleep in this species is about three hours.

Invariably on awakening, and often at other times, the ants perform, like many other insects, elaborate processes of washing and brushing. But, unlike other insects, ants assist one another in the performance of their toilet. The author just quoted describes the whole process in the genus *Atta*. The cleanser begins with washing the face of her companion, and then passes on to the thorax, legs, and abdomen.

> The attitude of the cleansed all this while is one of intense satisfaction, quite resembling that of a family dog when one is scratching the back of his neck. The insect stretches out her limbs, and, as her friend takes them successively into hand, yields them limp and supple to her manipulation; she rolls gently over on her side, even quite over on her back, and with all her limbs relaxed presents a perfect picture of muscular surrender and ease. The pleasure which the creatures take in being thus "combed" and "sponged" is really enjoyable to the observer. I have seen an ant kneel down before another and thrust forward the head drooping quite under the face, and lie there motionless, thus expressing, as plainly as sign-language could, her desire to be cleansed. I at once understood the gesture, and so did the supplicated ant, for she at once went to work.

Bates also has described similar facts with regard to ants of another genus—the *Ecitons*.

Play and Leisure.—The life of ants is not all work, or, at least, is not so in all species. Huber describes regular gymnastic sports as practiced by the species *pratensis*. They raise themselves on their hind-legs to wrestle and throw pretended antagonists with their fore-legs, run after each other, and seem to play at hide and seek. When one is victorious in a display of strength, it often seizes all the others in the ring, and tumbles them about like nine-pins. Forel has amply confirmed these observations of Huber, and says that the chasing, struggling, and rolling together upon the ground, pulling each other in and out of the entrances, etc., irresistibly reminded him of romping

boys at play. "I understand," he says, "that the matter must seem wonderful to those who have not witnessed it, particularly when we remember that sexual attraction can here play no part."

McCook and Bates also give similar accounts of the habits of play and leisure among species of the Western Hemisphere.

FUNERALS.—The habit of carrying their dead out and away from their nests is very general, if not universal, among ants ; and, being no doubt due to sanitary requirements, has probably been developed as a beneficial instinct by natural selection. McCook says of the agricultural ants :

All species whose manners I have closely observed are quite alike in their mode of caring for their own dead, and for the dry carcasses of aliens. The former they appear to treat with some degree of reverence, at least to the extent of giving them a sort of sepulture without feeding upon them. The latter, after having exhausted the juices of the body, they usually deposit together in some spot removed from the nest.

Experiments made on ants kept in confinement showed that the desire to remove dead companions was one of the strongest that they exhibited :

So great was the desire to get rid of the dead outside the nest, that the bearers would climb up the smooth surface of the glass to the very top of the jar, laboriously carrying with them a dead ant. This was severe work, which was rarely undertaken except under the influence of this funereal enthusiasm. Falls were frequent, but patiently the little "undertaker" would follow the impulse of her instinct and try and try again. Finally the fact of a necessity seemed to dawn upon the ants (the jar being closed at the top so that they could not get out), and a portion of the surface opposite from the entrance to the galleries, and close up against the glass, was used as a burial-ground and sort of kitchen-midden, where all the refuse of the nest was deposited.

This author also records in his recently published work an interesting piece of information to which he was led by Mrs. Treat :

A visit was paid to a large colony of these slave-makers (*F. sanguinea*), which is established on the grounds adjoining her residence at Vineland, New Jersey. I noticed that a number of carcasses of one of the slave species (*Formica fusca*) were deposited together quite near the gates of the nest. They were probably chiefly the dry bodies of ants brought in from recent raids. It was noticed that the dead ants were all of one species, and therefore Mrs. Treat informed me that the red slave-makers never deposited their dead with those of their black servitors, but always laid them by themselves, not in groups, but separately, and were careful to take them a considerable distance from the nest. One can hardly resist pointing out here another likeness between the customs of these social hymenoptera and those of human beings, certain of whom carry their distinctions of race, condition, or religious caste even to the gates of the cemetery, in which the poor body molders into its mother dust !—*Nineteenth Century*.

LUNAR LORE AND PORTRAITURE.

By F. E. FRYATT.

FROM the remotest periods of which we have quoted or written records, the moon has been an object of adoring and speculative contemplation. As the babe in the cradle, crowing and smiling, stretches out its tiny hands to grasp the shining flame of the distant candle, so the infant races of the world gazed at the radiant orb above them, seeking to grasp and penetrate its mystic beauties.

Nor is it to be marveled at, when we consider that this planet was the most brilliant and changeable, as well as the nearest and apparently largest celestial body that presented itself to their nightly view, and that in the clear, exquisite ether of Arabian skies, and the calm nights of India and Egypt, it shone among the heavenly host with a luster unknown to dwellers in the crowded cities of a northern clime.

But the children of these tropic lands did something more than gaze, speculate, and admire : with supreme patience they reared lofty towers and grand pyramids, and invented instruments which have led up step by step to the transit instrument, the micrometer, and the telescope of to-day. A college of astronomy was founded by the priesthood of Egypt, the worship of the moon growing out of their frequent use of her pictured or carved image in making their meteorological announcements to the people ; as, for instance, when the Nile was about to overflow, warning heralds were sent through the streets bearing aloft the familiar symbols of the river goddess, and a gilded figure of the moon in the phase it would present at the date of the expected rising.

In the course of time, the signification was forgotten, the symbol was worshiped, and finally what it represented deified. The moon no longer appeared to the unlettered populace as merely a brilliant lamp suspended from a revolving dome, and shining until extinguished by the waters of the ocean, but now was looked upon with awe as a region of sublime mysteries.

This veneration of the moon gradually spread with population to all parts of the world. We have records of ancient Chinese ceremonials ; relics found among Druidical remains in Western Europe ; accounts of astronomical picture-writings of a religious character, and lunar calendars of gold, silver, and stone, discovered in ancient temple-ruins in Mexico, Central and South America.

Among the buildings devoted to lunar worship may be mentioned the wonderful Temple of Diana at Ephesus, built at the combined expense of the nations of Asia, and the magnificent mansion of the moon adjoining the Temple of the Sun in ancient Cuzco ; this building was in form a pyramidal pavilion with doors and inclosures completely

incrusted with glittering silver. Within, on the southern wall, was a painting in white, presenting the moon as a beautiful woman; on either side along the eastern and western walls, on massive thrones of silver, were seated the dead queens of Peru, embalmed and arrayed in regal splendor.

In an elegant pavilion, covered with plates of the precious metal, adjoining the mansion, were apartments for the accommodation of her waiting-maids, the stars.

There was also an elaborate circular Temple of the Moon on a lofty hill near Quito, so arranged that the moonlight, falling through certain openings, shone directly on a silver image suspended from a blue roof emblazoned with stars.

Priesthoods and orders of priestesses existed in ancient Greece, Italy, India, Egypt, Britain, and America, fearful penalties attaching to broken vows or neglect of offices.

Many astronomers, whose quoted works are lost, flourished before Christ; their curious theories have been preserved in ancient writings of a later period. It is exceedingly interesting to trace, step by step, the changes of opinion wrought by gradual discovery in regard to the physical condition of the moon. This orb—variously supposed to be a brilliant disk-shaped body formed from mist congealed by fire; a mass of fiery and opaque elements; a circle of porous substance like pumice-stone, receiving light from a luminous ether; and a sphere, one half of which was burning—was finally pronounced by Anaxagoras, the Greek philosopher, in the year 500 B. C., to be an earth with mountains and valleys like our own.

For this opinion, and his belief that the moon was as large as the Peloponnesus, Anaxagoras was ridiculed by the learned men of his time. Six hundred years later, Plutarch supported the views of his ancient predecessor; but it was not until the application of the first telescope that any certain knowledge of the planet was gained. This instrument caused a complete revolution of ideas in astronomy. Galileo's plains, mountains, and valleys, were facts, whereas those of Anaxagoras had been matters of conjecture. Imagination soon peopled the moon with a peculiar race of beings, covered it with grand forests and cities, and all that pertains to a habitable world. Fortifications were discovered; consequently, the Lunarians were a warlike people. Certain bright points on the dark portion of the moon's disk were proclaimed to be conflagrations, or volcanic eruptions, or perhaps fireworks in honor of some lunar event.

A German astronomer proposed the building of an immense triangle on the plains of Siberia as a means of mathematical correspondence with the moon's inhabitants, believing they would build one in reply. A brother scientist, commenting on this novel signal-service, naïvely declared that "many more foolish projects had been carried out successfully."

Improved instruments have demonstrated that life, as we understand it, is impossible on the lunar body, revealing to us that it is composed of rocks and matter of a highly reflective character; its surface being broken up by ranges of lofty, perpendicular mountains, craters of elevation, precipitous caves and hollows; that the dark plains are the beds of oceans long ago evaporated or withdrawn into the interior of the planet; that it is subject to enormous degrees of heat and cold, has no water or apparent atmosphere, and, if so, neither wind, wave, nor sound.

Nothing varies the monotony of the long days and nights composing the lunar year, save the changing positions of the intensely black shadows falling from hills and mountains that cut off or fling back into space the white light of the sun; or the swift, silent fall of the crumbling walls of some hollow crater.

On looking at the moon through the telescope for the first time, one is struck by the melancholy character of its broken yet shining surface. Desolate plains are seen stretching away from the central view to the dazzling sunlit edge where, under the immedate solar glare, they seem sheeted with everlasting snow. To the right, as they gradually approach the region of darkness, the white softens into the greenish gray of a sandy desert.

But, ho! what tracks are these like the footprints of huge camels? Has some celestial caravan passed this way and disappeared from sight in the far south? Shall we see another wending its slow way after?

And yonder—another marvel—a fountain of silver sending from its argent depths rivers of precious metal to wander over sandy plains! Will the wonders never cease? Beyond, on the brilliant terminator, are promontories of pearly luster jutting out into seas of darkness, and, remoter still, pendent stars shining over ebon gulfs!

Gentle astronomer, increase your magnifying, for we long to investigate, space by space, this moon whose beauties we have never known before!

Ah, the footprints are footprints no longer—they are cup-shaped hollows innumerable! These drifts, as of snow, are ranges of mountains, and the promontories and pendent stars are crags and mountain-tops just catching the rays of dawn. Down their steep sides lie the shadows of night; the topmost peaks alone have caught the glory! And beyond is the night-side of the moon, illumined by dim earth-light.

The power is increased again, and now we are looking down into a crater, and behold! one, two, three mountains rising from its central depths; their peaks hardly reach the level of its ring-shaped summit!

Here is another crater, with a solitary peak rising from its bottom. See, down below, piles of rocks are lying around its base. Three miles deep, by measurement, what awful gulfs of darkness these at the new

moon, when no light falls within their silent hollows! What reservoirs of fiercest heat when, like a giant eye, the sun glares down and floods their unsheltered spaces!

Let us turn once more to those bright fountains and rivers of silver, astronomically called "rilles." Here they are, brilliant as ever; but we can learn nothing of their nature by gazing at them. The astronomer will tell you the latest theory—namely, that when the moon's crust was cooling, ages ago, it contracted, causing immense corrugations, wrinkles, and nodules, and in many places deep rents, admitting water to the heated nucleus, producing volcanic action; in many of these fissures rose up molten matter, filling the central openings to the brim, and extending all the length of the cracks.

You have already noticed that besides the craters there are innumerable craterlets. Your guide will explain again—referring to some great authority—the fanciful and plausible theory that these were the result of downfalls of meteoric rain when the lunar crust was still in the plastic state.

Let us observe the plains again: near the left border, under the sun-glare, they are too brilliant for definition of detail; near the central view their greenish-gray surfaces may be examined in the apparent twilight of the moon. Their seemingly smooth character and color prove them to be beds of oceans of the past lunar ages. These marine bottoms are not smooth in reality, but are seamed and traversed by ranges of hills and mountains, and craters thousands of feet deep! Did these, like monster mouths, swallow the remnants of the evaporating oceans?

The longer one studies this lonely globe, so beautiful in its desolation, the more real does it become to the eye. Here rise veritable mountains casting their black shadows on the plains. There stretch deserts thousands of miles in length, visible throughout all their breadth, for there is little if any perspective on the moon.

To the east is reigning the brilliant lunar day, so long, so fierce, so hot; beyond it is evening, with sunset touching the mountain-peaks on the terminator; in the remotest west, midnight!

This is more than one can see on one's own terrestrial ball, where the vision is bounded by atmosphere, and objects "by degrees grow beautifully less."

One must not look at the full moon to view all these wonders, for seen through the telescope it is merely a brilliant, dazzling sphere; mountains, valleys, and plains are flooded with intensest light; no shadows fall; the white glitter is intolerable!

It must be viewed in six phases: the three-days-old crescent, five-days' old, seven days' old or first quarter, the last quarter, and the last three days of the old moon; thus may be seen the four visible sevenths of the lunar globe, all that is ever seen by mortal eye.

From time immemorial the graphic art has been employed in repre-

senting the moon according to the prevailing theory of the time, as seen by the naked eye or through the telescope. In the picture-writings of both continents, in their carvings and metal castings, were seen the first rude presentations of the planet in her various phases.

The first astronomical moon-drawing is attributed to Anaxagoras; it was probably executed more than twenty-three centuries ago. Since his time numberless drawings have been made, all more or less imperfect. In 1609, Galileo, from observations made with a telescope of his own invention, constructed the first lunar map, which is valuable only as marking the first great advance toward precise knowledge of the moon's surface.

Scheiner, a German professor, and Schirlaus, made numerous sketches of a like character; during the same century Langrenus executed special drawings of different points on the moon, naming them after celebrated personages.

About the year 1647 appeared the "Selenographia," a work by Hevelius, of Dantzic, wherein was the first lunar map at all approaching correctness. Although Father Riccioli, of Bologna, published a chart in 1651, and Dominic Cassini another in 1680, fuller as to detail, Hevelius's chart was considered the best authority for one hundred years after its issue, his knowledge of drawing contributing greatly to its success.

In 1775 appeared Tobias Mayer's small lunar chart, the most accurate yet published, and consulted as such until 1824. The first scientific attempt to delineate the characteristic features of the moon in detail was made by Lohrmann, a land-surveyor in Dresden: he intended to publish a chart on a large scale in twenty-five sections, but failing eyesight compelled him to forego his ambitious project; he, however, executed a fine lunar map, fifteen and a quarter inches in diameter, in 1838.

Schroeter, of Lilienthal, labored with the greatest patience, making a long series of observations, but, owing to a lack of graphic skill, his "Selenographische Fragmente" was not a true exponent of his ideas.

In 1837 appeared Beer and Mädler's "Der Monde," one of the most valuable contributions to astronomical literature; the chart accompanying it shows an immense amount of detail, all the principal objects seen through the telescope being given in outline. Webb's "Map of the Moon," reduced from this chart, is of great value to the student, retaining as it does all the most important features and omitting confusing detail.

The most interesting and wonderful chart yet published is that recently completed by Schmidt, of Athens, the result of more than a quarter of a century's observations of the moon, and for which the author made more than a thousand drawings.

The most diffuse and clearly illustrated work published within the

last decade is Neison's "Moon," the accompanying chart in sections giving the principal features of the planet's surface. Nasmyth and Carpenter's "Moon," illustrated by fine photographs of prominent insulated peaks, mountain-ranges, and crateriform mountains, and Proctor's "Motions, Aspect, Scenery, and Physical Condition of the Moon," furnish delightful and instructive text to the general reader.

Very beautiful drawings of single craters, viewed under high power, have been made by Secchi, Nasmyth, and Carpenter. Bertch, Arnauld, Temple, and Harriot, a young English astronomer, have given us topographical lunar drawings of considerable merit.

The greatest change in lunar illustration occurred in the application of the telescope to photography. The moon, sighted by a telescope provided with a meniscus lens for the collection of the actinic rays, and kept in the field by the driving-clock, casts her image on a sensitive plate, which, being developed, gives all the numerous details of the lunar surface—dimly and minutely, to be sure, but capable of enlargement and printing to apparent life-size.

Draper photographed the moon in 1840; Bond, in 1850; De La Rue and Rutherfurd, in 1857, the former discovering that the pictures could be combined in the stereoscope so as to appear globular. Photographic representations of the moon, in her various phases, are eminently picturesque, though lacking distinct detail; they are, however, correct, for, granted that the apparatus is properly adjusted, the sun paints with perfect truth.

Neison's maps of the moon were first done in water-color. Some have also been done in this vehicle by the "Moon Committee" of the Royal Astronomical Society of London." It has been reserved for Henry Harrison, a young American astronomer and artist, to paint the first and only true telescopic portrait of the moon in oil-colors.

"Not difficult to do!" exclaims the uninitiated observer.

"Impossible!" returns the scientist. "No one can paint the moon in detail."

Nevertheless, our æsthetic astronomer set to work to paint the six phases, which would give a portrait not only picturesque, but so true to details and coloring that it could be offered to the scrutiny of eyes long practiced in the nightly study of the orb itself—eyes that would be quick to detect the absence of the smallest crater, the presence of a superfluous peak.

After the professional duties of the day, Mr. Harrison, when the weather was propitious, passed his time in making observations of the heavens. Seated at the telescope, he would pass hour after hour, studying the surface of the lunar orb.

On one of these occasions, a summer evening, singularly calm and clear, his wife joined him. Sitting for some time completely absorbed in the brilliant spectacle, she at last exclaimed: "Henry, paint that, if you can; it is beautiful beyond description!"

The thought had not then occurred to him. Now his wife's fanciful challenge awakened a desire to paint the moon in colors; for, as the most exquisite portrait in black and white can not express the bloom of lip and cheek, or the burnished gold of sunny tresses, neither could the various astronomical drawings now in existence express the beautiful gradations of light, the delicate tinting of the gray-green plains, the brilliant peaks and sunlit edge that make the telescopic moon the most interesting of celestial bodies.

Hitherto the human face and form had engaged his pencil: he could command sittings of his subject where and when he chose; direct the light and shade; arrange the drapery, select the pose: but here was to be another order of affairs; a willful, fitful queen, subject to no human wishes, obedient to no mortal command. There were only two evenings in the month in which to study the chosen phase—on one of them or both her Majesty might command the vapors of the air and veil herself in impenetrable cloud. Another month she might summon the forces of the winds, and dance with them a demon's dance upon the telescopic mirror; and, on the next night, when the chosen phase was past, appear serenely beautiful upon a field of stainless blue.

It may be fairly asked how the artist, contending with so many difficulties, could paint a faithful portrait at all. As it would be impossible in the moon's short sittings, if one may use the term, to catch and fix accurately the varied details that crowd its surface with the pencil alone, Mr. Harrison resorted, as a first step, to photographic aid. Taking Rutherfurd's negative of the three-days-old crescent, he enlarged it to the desired size by means of an oxyhydrogen light, throwing the image from the glass to his canvas. Thereon he sketched the outlines of the craters, plains, and mountain-ranges, as the enlarged negative indistinctly presented them. Then, by the light of a lantern suspended from the observatory roof, from time to time consulting the image of the moon mirrored in the telescope, he sharpened every detail, marking out the intensely black shadows and the equally intense high lights on the topmost peaks of the terminator, the dazzling edge, and the gradations of tint on the far-stretching plains.

Slowly—for eighteen months rolled by before the first phase was finished—pencil and pigment, guided by artist eye and hand, did their work, and there stood a faithful portrait of the three-days-old crescent, twenty-one inches in diameter, showing the terminator at Messier.

The edge toward the left is brilliantly illuminated by the sun, whose proximity casts a yellowish tint over the plains, that gradually fades into grayish-green in the shadows of night on the right edge or terminator. On the remainder of the disk, faintly illumined by earth-light, may be dimly seen outlines of the Apennine ranges, and the craters of Copernicus and Tycho.

The brilliant convexity of the moon is well thrown out by the clear

dark-blue of the sky in which it floats, the painted revelation of the wonders of a sister world. Plainer than words, this colored image tells the story of an activity of tempests, and bubbling caldrons of fire long since burned out; of oceans evaporated and drawn into the deepest depths of a dying world—of present silence and empty desolation!

Encouraged by the approval of famous scientists, who have examined and testified to the correctness and beauty of this first phase of the moon, Mr. Harrison has completed a second phase, and is at work on the remaining pictures, which are in various stages of progression.

Among the prominent features represented as seen on the telescopic moon at the first quarter may be mentioned the Mare Crisium, one of the darkest of all the regularly bordered mares or dark plains. Crisium shows a surface of a gray tint tinged with green. At times it is curiously dotted and streaked with light. The floor is traversed by ridges crossing each other and throwing up small peaks. At the first quarter appears Messier, on the terminator of the three-days-old crescent. Messier is a fine crater-plain, nine miles in diameter, inclosed by a bright mountain-wall. To the southeast rise the walls of Catharina, in some places reaching a height of sixteen thousand feet above the interior plain, which, under the highest magnifying power, shows a surface broken up into mounds, ridges, hills, and craterlets.

Lying to the northwest appears the Mare Fœcunditatis, the largest of the western mares or sea-beds, covering an area of one hundred and sixty thousand square miles, and penetrating, in bay-like indentations, into the mountain-ranges southward, Mare Tranquillitatis and Serenitatis, the latter one of the most prominent gray plains seen at the first quarter. The entire central portion of this mare shows a decided light-green tinge.

At the last quarter the most striking feature is Copernicus, the grandest ring-plain on the northern quadrant, and one of the most instructive. Its vast walls rise nearly twelve thousand feet above the level of the plateau, showing fifty magnificent peaks that shine at certain seasons like a crown of pearls on a radiant background. The central cones attain a height of nearly three thousand feet. On the inner side the walls fall abruptly in terraces to the floor, while, without, they slope gradually, and are broken into confused ridges, spreading away from their bases into hill and mountain chains.

Aristarchus, a brilliant ring-plain, is also visible at the last quarter; its broad, terraced walls rise twenty-six hundred feet above the moon's surface, and seven thousand five hundred above its own interior floor, nearly in the center of which stand two peaks and a small crater, the central peak being the most brilliant point visible on the moon. Among the bays, so called, seen on this quarter, is the Sinus Iridum, a dark, semicircular level, bordered by the magnificent cliffs of one of the most stupendous highlands of the moon, whose crest sends up at cer-

tain points towering peaks from fifteen to twenty thousand feet above the level of the dark plain.

The Mare Imbrium, also lying in the north quadrant, is the largest of the dark ring-plains of the moon. The lunar Carpathian and Apennine ranges bound it on the south, the Caucasus and Alps on the west, and on the north the lofty highlands of Plato and the Sinus Iridum. It has a length of seven hundred and fifty miles, and a breadth of six hundred and seventy-eight.

One of the most wonderful and mysterious features of the moon, and seen on the southern quadrant, is Tycho, the center of the principal streak system. From its mountain-walled plain issue streams of radiance like rivers of silver ; some of these "rilles" flow for a length of a thousand miles. The southern portion of the moon is a mass of old craters, ring-plains, valleys, hills, and ridges ; with its radiant streak system and diversity of formations it is the most interesting part of the lunar surface.

When completed, this series of paintings will present not only a worn-out world in miniature, but, if one may credit the great astronomers of our day, the painted prophecy of the far-off future of our own earth, when it shall have cooled off, and all the bustling, battling throngs of humanity be as its own clay !

THE VISIONS OF SANE PERSONS.

By FRANCIS GALTON.

IN the course of some recent inquiries into visual memory, I was greatly struck by the frequency of the replies in which my informants described themselves as subject to "visions." Those of whom I speak were sane and healthy, but were subject notwithstanding to visual presentations, for which they could not often account, and which in a few cases reached the level of hallucinations. This unexpected prevalence of a visionary tendency, among persons who form a part of ordinary society, seems to me suggestive and worthy of being put on record. In a previous article* I spoke of the faculty of summoning scenes at will, with more or less distinctness, before the visual memory ; in this I shall speak of the tendency among sane and healthy persons to see images flash unaccountably into existence.

Many of my facts are derived from personal friends of whose accuracy I have no doubt. Another group comes from correspondents who have written at length with much painstaking, and whose letters

* See a previous article on "Mental Imagery," "Popular Science Monthly," vol. xviii, p. 64.

appear to me to bear internal marks of scrupulous truthfulness. A third part has been collected for me by many kind friends in many countries, each of whom has made himself or herself an independent center of inquiry ; and the last, and much the most numerous portion, consists of brief replies by strangers to a series of questions contained in a circular that I drew up. I have gone over all this matter with great care, and have cross-tested it in many ways while it was accumulating, just as any conscientious statistician would, before I began to form conclusions. I was soon convinced of its substantial trustworthiness, and that conviction has in no way been shaken by subsequent experience. In short, the evidence of the four groups I have just mentioned is quite as consistent as could have been reasonably desired.

The lowest order of phenomena that admit of being classed as visions are the "Number forms" to which I have drawn attention on more than one occasion, but to which I must again very briefly allude. They are an abiding mental peculiarity in a certain proportion of persons (say five per cent.), who are unable as adults, and who have been ever unable as far back as they can recollect, to think of any number without referring it to its own particular habitat in their mental field of view. It there lies latent, but is instantly evoked by the thought or mention of it, or by any mental operation in which it is concerned. The thought of a series of consecutive numbers is therefore attended by a vision of them arranged in a perfectly defined and constant position, and this I have called a "Number form." Its origin can rarely be referred to any nursery diagram, to the clock-face, or to any incident of childhood. Nay, the form is frequently unlike anything the child could possibly have seen, reaching in long vistas and perspectives, and in curves of double curvature. I have even had to get wire models made by some of my informants in explanation of what they wished to convey. The only feature that all the forms have in common is their dependence in some way or other upon the method of verbal counting, as shown by their angles and other divisions occurring at such points as those where the 'teens begin, at the twenty's, thirty's and so on. The forms are in each case absolutely unchangeable, except through a gradual development in complexity. Their diversity is endless, and the Number forms of different men are mutually unintelligible.

These strange "visions," which are extremely vivid in some cases, are almost incredible to the vast majority of mankind, who would set them down as fastastic nonsense, but they are familiar parts of the mental furniture of the rest, where they have grown naturally, and where they remain unmodified and unmodifiable by teaching. I have received many touching accounts of their childish experiences from persons who see the Number forms, and the other curious visions of which I shall speak. As is the case with the color-blind, so with these

seers. They imagined at first that everybody else had the same way of regarding things as themselves. Then they betrayed their peculiarities by some chance remark which called forth a stare of surprise, followed by ridicule and a sharp scolding for their silliness, so that the poor little things shrunk back into themselves, and never ventured again to allude to their inner world. I will quote just one of many similar letters as a sample. I received this, together with much interesting information, immediately after a lecture I gave last autumn to the British Association at Swansea,* in which I had occasion to speak of the Number forms. The writer says :

> I had no idea, for many years, that every one did not imagine numbers in the same positions as those in which they appear to me. One unfortunate day I spoke of it, and was sharply rebuked for my absurdity. Being a very sensitive child, I felt this acutely, but nothing ever shook my belief that, absurd or not, I always saw numbers in this particular way. I began to be ashamed of what I considered a peculiarity, and to imagine myself, from this and various other mental beliefs and states, as somewhat isolated and peculiar. At your lecture the other night, though I am now over twenty-nine, the memory of my childish misery at the dread of being peculiar came over me so strongly that I felt I must thank you for proving that, in this particular, at any rate, my case is most common.

The next form of vision of which I will speak is the instant association of color with sound, which characterizes a small percentage of adults, but apears to be rather common, though in an ill-developed degree, among children. I can here appeal not only to my own collection of facts, but to those of others, for the subject has latterly excited some interest in Germany. The first widely known case was that of the brothers Nussbaumer, published in 1873 by Professor Bruhl, of Vienna, of which the English reader will find an account in the last volume of Lewis's "Problems of Life and Mind," page 280. Since then many occasional notices of similar associations have appeared, but I was not aware that it had been inquired into on a large scale by any one but myself. However, I was gratified by meeting with a pamphlet a few weeks ago, just published in Leipsic by two Swiss investigators, Messrs. Bleuler and Lehmann. Their collection of cases is fully as large as my own, and their results in the more important matters are similar to mine. One of the two authors had the faculty very strongly, and the other had not ; so they worked conjointly with advantage. As my present object is to subordinate details to the general impression that I wish to convey of the visionary tendency of certain minds, I will simply remark, first, that the persistence of the color association with sounds is fully as remarkable as that of the Number form with numbers. Secondly, that the vowel-sounds chiefly evoke them. Thirdly, that the seers are invariably most minute in their description of the precise tint and hue of the

* See "Fortnightly Review," September, 1880.

color. They are never satisfied, for instance, with saying "blue," but will take a great deal of trouble to express or to match the particular blue they mean. Lastly, no two people agree, or hardly ever do so, as to the color they associate with the same sound. I have one of the most extraordinary diagrams of these color associations that has, I suppose, ever been produced. It has been drawn by Mr. J. Key, of Graham's Town, South Africa. He sent me in the first instance a communication on the subject, which led to further correspondence, and eventually to the production of this diagram of colors in connection with letters and words. I have no reason to doubt its trustworthiness, and am bound to say that, strange as it looks, and elaborate as it is, I have other written accounts that almost match it.

A third curious and abiding fantasy of certain persons is invariably to connect visualized pictures with words, the same picture to the same word. I have collected many cases of this, and am much indebted to the authoress, Mrs. Haweis, who sees these pictures, for her kindness in sketching some of them for me, and her permission to use her name in guarantee of their genuineness. She says:

> Printed words have always had faces to me: they had definite expressions, and certain faces made me think of certain words. The words had *no* connection with these except sometimes by accident. The instances I give are few and ridiculous. When I think of the word Beast, it has a face something like a gargoyle. The word Green has also a gargoyle-face, with the addition of big teeth. The word Blue blinks and looks silly, and turns to the right. The word Attention has the eyes greatly turned to the left. It is difficult to draw them properly, because, like "Alice's" "Cheshire cat," which at times became a grin without a cat, these faces have expression without features. The expression, of course [note the *naïve* phrase, "of course."—F. G.], depends greatly on those of the letters, which have likewise their faces and figures. All the little a's turn their eyes to the left; this determines the eyes of Attention. Ant, however, looks a little down. Of course, these faces are endless as words are, and it makes my head ache to retain them long enough to draw.

Some of the figures are very quaint. Thus the interrogation "what?" always excites the idea of a fat man cracking a long whip. They are not the capricious creations of the fancy of the moment, but are the regular concomitants of the words, and have been so as far back as the memory is able to recall.

When in perfect darkness, if the field of view be carefully watched, many persons will find a perpetual series of changes to be going on automatically and wastefully in it. I have much evidence of this. I will give my own experience the first, which is striking to me, because I am very unimpressionable in these matters. I visualize with effort; I am peculiarly inapt to see "after-images," "phosphenes," "light-dust," and other phenomena due to weak sight or sensitiveness; and, again, before I thought of carefully trying, I should have emphatically declared that my field of view in the dark was essentially of a

uniform black, subject to an occasional light-purple cloudiness and other small variations. Now, however, after habituating myself to examine it with the same sort of strain that one tries to decipher a sign-post in the dark, I have found out that this is by no means the case, but that a kaleidoscopic change of patterns and forms is continually going on, but they are too fugitive and elaborate for me to draw with any approach to truth. My deficiencies, however, are well supplied by other drawings in my possession. They are by the Rev. George Henslow, whose visions are far more vivid than mine. His experiences are not unlike those of Goethe, who said, in an often-quoted passage, that, whenever he bent his head and closed his eyes and thought of a rose, a sort of rosette made its appearance, which would not keep its shape steady for a moment, but unfolded from within, throwing out a succession of petals, mostly red, but sometimes green, and that it continued to do so without change in brightness and without causing him any fatigue so long as he cared to watch it. Mr. Henslow, when he shuts his eyes and waits, is sure, in a short time, to see before him the clear image of some object or other, but usually not quite natural in its shape. It then begins to change from one object to another, in his case, also, for as long a time as he cares to watch it. Mr. Henslow has zealously made repeated experiments on himself, and has drawn what he sees. He has also tried how far he is able to mold the visions according to his will. In one case, after much effort, he contrived to bring the imagery back to its starting-point, and thereby to form what he terms a "visual cycle." The following account is extracted and condensed from his very interesting letter:

The first image that spontaneously presented itself was a cross-bow; this was immediately provided with an arrow, remarkable for its pronounced barb and superabundance of feathering. Some person, but too indistinct to recognize much more of him than the hands, appeared to shoot the arrow from the bow. The single arrow was then accompanied by a flight of arrows from right to left, which completely occupied the field of vision. These changed into falling stars, then into flakes of a heavy snow-storm; the ground gradually appeared as a sheet of snow where previously there had been vacant space. Then a well-known rectory, fish-ponds, walls, etc., all covered with snow, came into view most vividly and clearly defined. This somehow suggested another view, impressed on his mind in childhood, of a spring morning, brilliant sun, and a bed of red tulips: the tulips gradually vanished except one, which appeared now to be isolated and to stand in the usual point of sight. It was a single tulip, but became double. The petals then fell off rapidly in a continuous series until there was nothing left but the pistil, but (as is almost invariably the case with his objects) that part was greatly exaggerated. The stigmas then changed into three branching brown horns; then into a knob, while the stalk changed into a stick. A slight bend in it seems to have suggested a center-bit; this passed into a sort of pin passing through a metal plate; this again into a lock, and afterward into a nondescript shape, distantly suggestive of the original cross-bow. Here Mr. Henslow endeavored to force his will upon the visions, and to reproduce the cross-bow, but the first attempt was an utter failure. The figure

changed into a leather strap with loops, but while he still endeavored to change it into a bow the strap broke, the two ends were separated, but it happened that an imaginary string connected them. This was the first concession of his automatic chain of thoughts to his will. By a continued effort the bow came, and then no difficulty was felt in converting it into the cross-bow and thus returning to the starting-point.

I have a sufficient variety of cases to prove the continuity between all the forms of visualization, beginning with an almost total absence of it, and ending with a complete hallucination. The continuity is, however, not simply that of varying degrees of intensity, but of variations in the character of the process itself, so that it is by no means uncommon to find two very different forms of it concurrent in the same person. There are some who visualize well and who also are seers of visions, who declare that the vision is not a vivid visualization, but altogether a different phenomenon. In short, if we please to call all sensations due to external impressions "*direct*," and all others "*induced*," then there are many channels through which the induction may take place, and the channel of ordinary visualization in the persons just mentioned is very different from that through which their visions arise.

The following is a good instance of this condition. A friend writes:

These visions often appear with startling vividness, and, so far from depending on any voluntary effort of the mind, they remain when I often wish them very much to depart, and no effort of the imagination can call them up. I lately saw a framed portrait of a face which seemed more lovely than any painting I have ever seen, and again I often see fine landscapes which bear no resemblance to any scenery I have ever looked upon. I find it difficult to define the difference between a waking vision and a mental image, although the difference is very apparent to myself. I think I can do it best in this way: If you go into a theatre and look at a scene, say of a forest by moonlight, at the back part of the stage, you see every object distinctly and sufficiently illuminated (being thus unlike a mere act of memory), but it is nevertheless vague and shadowy, and you might have difficulty in telling afterward all the objects you have seen. This resembles a mental image in point of clearness. The waking vision is like what one sees in the open street in broad daylight, when every object is distinctly impressed on the memory. The two kinds of imagery differ also as regards voluntariness, the image being entirely subservient to the will, the visions entirely independent of it. They differ also in point of suddenness, the images being formed comparatively slowly as memory recalls each detail, and fading slowly as the mental effort to retain them is relaxed; the visions appearing and vanishing in an instant. The waking visions seem quite close, filling as it were the whole head, while the mental image seems farther away in some far-off recess of the mind.

The number of persons who see visions no less distinctly than this correspondent is much greater than I had any idea of when I began this inquiry. I have in my possession the sketch of one, prefaced by a description of it by Mrs. Haweis. She says:

All my life long I have had one very constantly recurring vision, a sight which came whenever it was dark or darkish, in bed or otherwise. It is a flight of pink roses floating in a mass from left to right, and this cloud or mass of roses is presently effaced by a flight of "sparks" or gold speckles across them. The sparks totter or vibrate from left to right, but they fly distinctly upward: they are like tiny blocks, half gold, half black, rather symmetrically placed behind each other, and they are always in a hurry to efface the roses: sometimes they have come at my call, sometimes by surprise, but they are always equally pleasing. What interests me most is, that when a child under nine the flight of roses was light, slow, soft, close to my eyes, roses so large and brilliant and palpable that I tried to touch them: the *scent* was overpowering, the petals perfect, with leaves peeping here and there, texture and motion all natural. They would stay a long time before the sparks came, and they occupied a large area in black space. Then the sparks came slowly flying, and generally, not always, effaced the roses at once, and every effort to retain the roses failed. Since an early age the flight of roses has annually grown smaller, swifter, and farther off, till by the time I was grown up my vision had become a speck, so instantaneous that I had hardly time to realize that it was there before the fading sparks showed that it was past. This is how they still come. The pleasure of them is past, and it always depresses me to speak of them, though I do not now, as I did when a child, connect the vision with any elevated spiritual state. But, when I read Tennyson's "Holy Grail," I wondered whether anybody else had had my vision—"Rose-red, with beatings in it." I may add, I was a London child who never was in the country but once, and I connect no particular flowers with that visit. I may almost say that I had never seen a rose, certainly not a quantity of them together.

A common form of vision is a phantasmagoria, or the appearance of a crowd of phantoms, perhaps hurrying past like men in a street. It is occasionally seen in broad daylight, much more often in the dark; it may be at the instant of putting out the candle, but it generally comes on when the person is in bed, preparing to sleep, but is by no means yet asleep. I know no less than three men, eminent in the scientific world, who have these phantasmagoria in one form or another. A near relative of my own had them in a marked degree. She was eminently sane, and of such good constitution that her faculties were hardly impaired until near her death at ninety. She frequently described them to me. It gave her amusement during an idle hour to watch these faces, for their expression was always pleasing, though never strikingly so. No two faces were ever alike, and they never resembled that of any acquaintance. When she was not well the faces usually came nearer to her, sometimes almost suffocatingly close. She never mistook them for reality, although they were very distinct. This is quite a typical case, similar in most respects to many others that I have.

A notable proportion of sane persons have had not only visions, but actual hallucinations of sight, sound, or other sense, at one or more periods of their lives. I have a considerable packet of instances contributed by my personal friends, besides a large number communicated

to me by other correspondents. One lady, a distinguished authoress, who was at the time a little fidgeted, but in no way overwrought or ill, said that she saw the principal character of one of her novels glide through the door straight up to her. It was about the size of a large doll, and it disappeared as suddenly as it came. Another lady, the daughter of an eminent musician, often imagines she hears her father playing. The day she told me of it the incident had again occurred. She was sitting in a room with her maid, and she asked the maid to open the door that she might hear the music better. The moment the maid got up the hallucination disappeared. Again, another lady, apparently in vigorous health, and belonging to a vigorous family, told me that during some past months she had been plagued by voices. The words were at first simple nonsense; then the word "pray" was frequently repeated; this was followed by some more or less coherent sentences of little import, and finally the voices left her. In short, the familiar hallucinations of the insane are to be met with far more frequently than is commonly supposed, among people moving in society and in normal health.

I have now nearly done with my summary of facts; it remains to make a few comments on them.

The weirdness of visions lies in their sudden appearance, in their vividness while present, and in their sudden departure. An incident in the Zoölogical Gardens struck me as a helpful simile. I happened to walk to the seal-pond at a moment when a sheen rested on the unbroken surface of the water. After waiting a while I became suddenly aware of the head of a seal, black, conspicuous, and motionless, just as though it had always been there, at a spot on which my eye had rested a moment previously and seen nothing. Again, after a while, my eye wandered, and, on its returning to the spot, the seal was gone. The water had closed in silence over its head without leaving a ripple, and the sheen on the surface of the pond was as unbroken as when I first reached it. Where did the seal come from, and whither did it go? This could easily have been answered if the glare had not obstructed the view of the movements of the animal under water. As it was, a solitary link in a continuous chain of actions stood isolated from all the rest. So it is with the visions; a single stage in a series of mental processes emerges into the domain of consciousness. All that precedes and follows lies outside of it, and its character can only be inferred. We see in a general way, that a condition of the presentation of visions lies in the over-sensitiveness of certain tracks or domains of brain-action, and the under-sensitiveness of others; certain stages in a mental process being vividly represented in consciousness while the other stages are unfelt. It is also well known that a condition of partial hyperæsthesia and partial anæsthesia is a frequent functional disorder, markedly so among the hysterical and hypnotic, and an organic disorder among the insane. The abundant facts that I have collected

show that it may also coexist with all the appearances of good health and sober judgment.

A convenient distinction is made between hallucinations and illusions. Hallucinations are defined as appearances wholly due to fancy; illusions, as misrepresentations of objects actually seen. There is, however, a hybrid case which deserves to be specifically classed, and arising in this way: Vision, or any other sensation, may, as already stated, be a "direct" sensation excited in the ordinary way through the sense-organs, or it may be an "induced" sensation excited from within. We have, therefore, direct vision and induced vision, and either of these may be the ground of an illusion. So we have three cases to consider, and not two. There is simple hallucination, which depends on induced vision justly observed; there is simple illusion, which depends on direct vision fancifully observed; and there is the hybrid case of which I spoke, which depends on induced vision fancifully observed. The problems we have to consider are, on the one hand, those connected with induced vision, and, on the other hand, those connected with the interpretation of vision, whether the vision be direct or induced.

It is probable that much of what passes for hallucination proper belongs in reality to the hybrid case, being an illusive interpretation of some induced visual cloud or blur. I spoke of the ever-varying patterns in the field of view; these, under some slight functional change, might easily become more consciously present, and be interpreted into phantasmal appearances. Many cases, if space allowed, could be adduced to support this view.

I will begin, then, with illusions. What is the process by which they are established? There is no simpler way of understanding it than by trying, as children often do, to see "faces in the fire," and to carefully watch the way in which they are first caught. Let us call to mind at the same time the experience of past illnesses, when the listless gaze wandered over the patterns on the wall-paper and the shadows of the bed-curtains, and slowly evoked faces and figures that were not easily laid again. The process of making the faces is so rapid in health that it is difficult to analyze it without the recollection of what took place more slowly when we were weakened by illness. The first essential element in their construction is, I believe, the smallness of the area upon which the attention is directed at any instant, so that the eye has to move much before it has traveled over every part of the object toward which it is directed. It is as with a plow, that must travel many miles before the whole of a small field can be tilled, but with this important difference—the plow travels methodically up and down in parallel furrows; the eye wanders in devious curves, with abrupt bends, and the direction of its course at any instant depends on four causes: on the most convenient muscular motion in a general sense, on idiosyncrasy, on the mood, and on the associations current at

the moment. The effect of idiosyncrasy is excellently illustrated by the "Number forms," where we saw that a very special sharply defined track of mental vision was preferred by each individual who sees them. The influence of the mood of the moment is shown in the curves that characterize the various emotions, as the lank, drooping lines of grief, which make the weeping-willow so fit an emblem of it. In constructing fire-faces it seems to me that the eye in its wanderings follows a favorite course, and notices the points in the pictures at large that coincide with its course. It feels its way, easily diverted by associations based on what has just been noticed, and so, by the unconscious practice of a system of "trial and error," at last finds a track that will suit—one that is easy to follow, and that also makes a complete picture. The process is essentially the same as that of getting a clear idea from out of a confused multitude of facts. The fancy picture is dwelt upon, all that is incongruous with it becomes disregarded, while all deficiencies in it are supplied by the fantasy. These latest stages are easily represented after the fashion of a diorama. Three lanterns are made to converge on the same screen. The first throws an image of what the imagination will discard, the second of that which it will retain, the third of that which it will supply. Turn on the first and second, and the picture on the screen will be identical with that which fell on the retina. Shut off the first and turn on the third, and the picture will be identical with the illusion.

Visions, like dreams, are often mere patchworks built up of bits of recollections. The following is one of these:

When passing a shop in Tottenham Court Road, I went in to order a Dutch cheese, and the proprietor (a bullet-headed man whom I had never seen before) rolled a cheese on the marble slab of his counter, asking me if that one would do. I answered "Yes," left the shop, and thought no more of the incident. The following evening, on closing my eyes, I saw a head detached from the body rolling about slightly on a white surface. I recognized the face, but could not remember where I had seen it, and it was only after thinking about it for some time that I identified it as that of the cheesemonger who had sold me the cheese on the previous day. I may mention that I have often seen the man since, and that I found the vision I saw was exactly like him, although, if I had been asked to describe the man before I saw the vision, I should have been unable to do so.

Recollections need not be joined like mosaic-work; they may be blended, on the principle I described two years age, of making composite portraits. I showed that if two lanterns were converged upon the same screen, and the portrait of one person was put into one and that of another person into the other, the portraits being taken under similar aspects and states of light and shade, then on adjusting the two images eye to eye and mouth to mouth, and so superposing them as exactly as the conditions admitted, a new face will spring into existence. It will have a striking appearance of individuality, and will bear a family likeness to each of its constituents. I also showed that these

composite portraits admitted of being made photographically * from a large number of components. I suspect that the phantasmagoria may be due to blended memories; the number of possible combinations would be practically endless, and each combination would give a new face. There would thus be no limit to the dies in the coinage of the brain.

I have tried a modification of this process with but small success, which will at least illustrate a cause of the tendency in many cases to visualize grotesque forms. My object was to efface from a portrait that which was common among persons of the same race, and therefore too familiar to attract attention, and to leave whatever was peculiar in it. I proceeded on the following principle: We all know that the photographic negative is the converse (or nearly so) of the photographic positive, the one showing whites where the other shows blacks, and *vice versa.* Hence the superposition of a negative upon a positive transparency of the same portrait tends to create a uniform smudge. By superposing a negative transparency of a *composite* portrait on a positive of any one of the *individual* faces from which it was composed, all that is common to the group ought to be smudged out, and all that is personal and peculiar to that face ought to remain.

I have found that the peculiarities of visualization, such as the tendency to see Number-forms, and the still rarer tendency to associate color with sound, is strongly hereditary, and I should infer, what facts seem to confirm, that the tendency to be a seer of visions is equally so. Under these circumstances we should expect that it would be unequally developed in different races, and that a large natural gift of the visionary faculty might become characteristic not only of certain families, as among the second-sight seers of Scotland, but of certain races, as that of the gypsies.

It happens that the mere acts of fasting, of want of sleep, and of solitary musing, are severally conducive to visions. I have myself been told of cases in which persons accidentally long deprived of food became subject to them. One was of a pleasure-party driven out to sea, and not being able to reach the coast till nightfall, at a place where they got shelter but nothing to eat. They were mentally at ease and conscious of safety, but they were all troubled with visions, half dreams and half hallucinations. The cases of visions following protracted wakefulness are well known, and I also have collected a few. As regards the effect of solitariness, it may be sufficient to allude to the recognized advantages of social amusements in the treatment of the insane. It follows that the spiritual discipline undergone for purposes of self-control and self-mortification has also the incidental effect of producing visions. It is to be expected that these should often bear a close relation to the prevalent subjects of thought, and,

* I have latterly much improved the process, and hope shortly to describe it elsewhere.

although they may be really no more than the products of one portion of the brain, which another portion of the same brain is engaged in contemplating, they often, through error, receive a religious sanction. This is notably the case among half-civilized races.

The number of great men who have been once, twice, or more frequently subject to hallucinations is considerable. A list, to which it would be easy to make large additions, is given by Brierre de Boismont ("Hallucinations," etc., 1862), from whom I translate the following account of the star of the first Napoleon, which he heard, second-hand, from General Rapp:

> In 1806, General Rapp, on his return from the siege of Dantzic, having occasion to speak to the Emperor, entered his study without being announced. He found him so absorbed that his entry was unperceived. The General, seeing the Emperor continue motionless, thought he might be ill, and purposely made a noise. Napoleon immediately roused himself, and without any preamble, seizing Rapp by the arm, said to him, pointing to the sky, "Look there, up there." The General remained silent, but, on being asked a second time, he answered that he perceived nothing. "What!" replied the Emperor, "you do not see it? It is my star, it is before you, brilliant"; then animating by degrees, he cried out, "It has never abandoned me, I see it on all great occasions, it commands me to go forward, and it is a constant sign of good fortune to me."

It appears that stars of this kind, so frequently spoken of in history, and so well known as a metaphor in language, are a common hallucination of the insane. Brierre de Boismont has a chapter on the stars of great men. I can not doubt that fantasies of this description were in some cases the basis of that firm belief in astrology which not a few persons of eminence formerly entertained.

The hallucinations of great men may be accounted for in part by their sharing a tendency which we have seen to be not uncommon in the human race, and which, if it happens to be natural to them, is liable to be developed in their overwrought brains by the isolation of their lives. A man in the position of the first Napoleon could have no intimate associates; a great philosopher who explores ways of thought far ahead of his contemporaries must have an inner world in which he passes long and solitary hours. Great men are also apt to have touches of madness; the ideas by which they are haunted, and to whose pursuit they devote themselves, and by which they rise to eminence, have much in common with the monomania of insanity. Striking instances of great visionaries may be mentioned, who had almost beyond doubt those very nervous seizures with which the tendency to hallucinations is intimately connected. To take a single instance, Socrates, whose *daimon* was an audible not a visual appearance, was subject to what admits of hardly any other interpretation than cataleptic seizure, standing all night through in a rigid attitude.

It is remarkable how largely the visionary temperament has manifested itself in certain periods of history and epochs of national life.

My interpretation of the matter, to a certain extent, is this: That the visionary tendency is much more common among sane people than is generally suspected. In early life, it seems to be a hard lesson to an imaginative child to distinguish between the real and visionary world. If the fantasies are habitually laughed at, the power of distinguishing them becomes at length learned; any incongruity or nonconformity is noted, the vision is found out and discredited, and is no further attended to. In this way the tendency to see them is blunted by repression. Therefore, when popular opinion is of a matter-of-fact kind, the seers of visions keep quiet; they do not like to be thought fanciful or mad, and they hide their experiences, which only come to light through inquiries such as these that I have been making. But let the tide of opinion change and grow favorable to supernaturalism, then the seers of visions come to the front. It is not that a faculty previously non-existent has been suddenly evoked, but one that had been long smothered is suddenly allowed expression and to develop, without safeguards, under the free exercise of it.—*Fortnightly Review.*

SCHOOL-ROOM VENTILATION.

By P. J. HIGGINS, M. D.

VENTILATION is the supply of fresh air to an apartment, and the removal of impure or vitiated air therefrom. An adequate supply of free oxygen is absolutely necessary to animal life; and, the higher we ascend in the scale of that life, the greater the quantity of oxygen consumed, and the more urgent the necessity for its consumption. In the atmosphere this oxygen exists in a free state—in mechanical solution—and in the form and proportion in which it is most easily assimilable. From the atmosphere, the animal absorbs it by means of its breathing apparatus which provides for its absorption by the blood, and the blood carries it to the tissues. *Pure air* consists of a mechanical mixture of about four fifths nitrogen and one fifth oxygen, with traces of ammonia, and about one part in two thousand of carbonic-acid gas (CO_2). These latter (ammonia and CO_2), from their small amount, may be neglected.

Air becomes vitiated for breathing purposes by holding in solution other gases or substances whose presence interferes with the appropriation of oxygen by the animal, or, being themselves absorbed, exert a toxic influence upon the vital fluid and tissues of the body. Hence to secure an adequate supply of fresh air, and the removal of impurities that accumulate therein, are the objects of ventilation. In this paper school-room ventilation only will be considered.

A full-grown person breathes on an average about twenty times

per minute, and takes in over twenty cubic inches of air at each inspiration. Boys and girls inspire somewhat less than twenty cubic inches, but breathe more rapidly than an adult—say twenty-five times per minute. In five minutes each will breathe over a cubic foot of air, and in a two-hours session nearly twenty-five cubic feet: so that, in a school of forty pupils, one thousand cubic feet will be inhaled every two hours. This is under, rather than above, the average.

Oxygen to the amount of nearly five per cent. of the quantity inhaled disappears at every breath, being absorbed by the blood—or twenty cubic inches per minute, for each individual—representing a total of fifty cubic feet for a school of forty pupils during a two-hours session. But, in addition to the consumption of oxygen, the air is further deteriorated by the exhalation of nearly as much carbonic-acid gas (CO_2) as there is oxygen consumed—say forty-five cubic feet in two hours, about one fortieth of the total amount produced being thrown off by the cutaneous surface of the body. Each cubic foot of carbonic-acid gas contains nearly half an ounce of pure carbon, or twenty-three ounces in all: so that, by breathing, forty mouths—like veritable little chimneys—puff out in two hours an amount equal to about a pound and a half of solid carbon. This is injurious in two ways, each of which will be examined in the proper place.

The air occasionally contains many impurities, but only those usually found in the school-room will here be enumerated. They are carbonic oxide (CO), carbonic-acid gas (CO_2), ammonia (NH_3), sulphur (S), sulphuretted hydrogen (H_3S)—all in the gaseous form; to which must be added aqueous vapor, organic matters, inorganic matters, epithelial cells, and animal exhalations.

The most toxic of all these is undoubtedly carbon monoxide (CO). It is a product of the incomplete combustion of carbon (C), but happily it is not usually found in the school-room in any large amount. A fire is the result of the chemical combination of the carbon of coal, or other combustible, with the oxygen (O) of the air; the atoms of the gas rush into combination with those of the carbon, and the arrested motion is transformed into heat—aqueous vapor (H_2O), carbon monoxide (CO), and carbonic-acid gas (CO_2), being produced. If a sufficient supply of air has free access to the *lower* portions of the fire, carbonic-acid gas is directly formed; but this in its passage upward through the central portion of the fire, where the temperature is higher, takes up another atom of carbon ($CO_2+C=CO+CO$) and becomes carbon monoxide, or carbonic oxide, as it is commonly called. This carbonic oxide, on reaching the upper surface of the fire, takes up an additional atom of oxygen from the air, and, burning with a bluish flame, becomes carbonic-acid gas once more, and makes its escape by the chimney. But usually a portion of the carbonic oxide fails to take up the additional atom of oxygen; and, when the supply of air is limited, the amount is increased, so that more or less car-

bonic oxide passes up the chimney along with the other gases of combustion. As the products of combustion are much lighter than the surrounding atmosphere—volume for volume—on account of their much higher temperature, and as the expansibility of gases is very great, they exert a pressure upon the sides of the pipe or flue through which they ascend. This being the case, these gases will escape through chinks, holes, or defective joints, along their course, like steam through a leaky conduit. Downward air-currents in the flue, and lateral currents from open windows, etc., occasionally blow large quantities of the gases of combustion through the open door of the stove, or through seams or cracks therein; and in these two ways—through stove and flue—sulphur, carbonic oxide, and carbonic-acid gas, may find their way into the room. It is claimed by some physicists that carbonic oxide will make its way through heated iron, and thus escape through the sides of the stove, but the quantity given out in this way—if, indeed, any is so given out, of which there is a reasonable doubt—must be so small that it is practically of no account, while quantities large enough to be decidedly injurious may issue through the door and other openings. Of course, these remarks apply only to schools heated by stoves; but it must not be forgotten that in rural districts, and many cities, all the schools are still heated in this way.

Carbonic oxide is a deadly poison, fixing itself in the blood-corpuscles and paralyzing them so that they can not carry on the function of respiration. To the inhalation of this gas is chiefly due the pale color of those who spend much time in apartments heated by stoves and poorly ventilated. Its presence can not be recognized by the senses, as it is tasteless, colorless, and inodorous.

Carbonic acid is produced in two ways, as before explained—by combustion and by breathing. The quantity thrown off in breathing is very much increased—often nearly doubled—during *active digestion*. As the fullest meal is taken at dinner, and digestion is most active soon after, it follows that the exhalation of carbonic-acid gas is greatest during the early part of the afternoon, and therefore during this time ventilation needs more attention. Of all the impurities found in the school-room, this is vastly the largest in amount, and popularly considered the most important. It is once and a half as heavy as air. At first sight, it might be supposed that, being heavier than air, it would sink to the floor and settle there in a layer of uniform height and density, like so much water. But this is not the case, for it is even more expansible than air. (Coefficient of expansion of air = ·00366; of CO_2 = ·00371.) Now, the law which governs the mixtures of gases is this:

The mixture of gases in free communication, whatever their density, takes place rapidly, and is homogeneous—that is, the mixture contains the gases in the same proportion; so that the percentage of carbonic-acid gas is about the same in all parts of the room.

If ample provision is not made for the removal of the vitiated air, the proportion of carbonic-acid gas continues to increase; and, as it is much heavier than air, the density becomes greater. Now, this increase of the air's density interferes with and retards the diffusion between the impure gases held in solution in the blood and the oxygen of the atmosphere—in other words, interferes with respiration. The consequence is, that the blood is not purified of the carbonic-acid gas which it holds in solution and combination. Not being removed as fast as it is formed in the body, it accumulates in the blood; the blood carries it throughout the system, circulating it through the delicate tissues of the brain. As the brain is the organ of the mind, it is by and through the brain that we think, reason, memorize, learn. For its healthy and vigorous action, a full supply of pure blood is an imperious necessity. The effects produced by this gas, when circulating through the brain in excess, are drowsiness, dizziness, dull headache, an inability to fix the attention, a dislike for application, a weakening of the memory, and a general torpor of the intellectual powers. An explanation of how and why these effects are produced would involve certain principles of mental physiology—a subject not within the scope of this paper.

Special attention is requested to this statement by Dr. Routh:* "Experiment has shown that if an animal be kept confined in a narrow, closed apartment, so that the air supplied is always more or less vitiated by the carbonic acid which it expires, however well fed that animal may be, tubercle (consumption) will be developed in about three months." If this be the case, a large percentage of cases of consumption should be met with among the inmates of badly ventilated schools. But, fortunately, the disease is comparatively infrequent under the age of fifteen, and added to this is the protecting influence of the active exercise in the open air usually indulged in by school-children. It is upon the teachers that its blighting effects are most apparent, as they are predisposed by age, they neglect exercise in the open air, and *their mental labor is severe, and worry of mind exhausting*. Of eleven teachers who died during the last eight years within the limits of one county in Pennsylvania, two died of acute disease, one of an overdose of an habitual narcotic, and of nine attacked by consumption, eight died—six ladies and one gentleman; the other, a gentleman, will recover, at least for a time.

The organic matters suspended in the air are derived (*a*) from the body; (*b*) from other sources. Epithelial cells or scales, very minute, arise by desquamation from the external cutaneous surface, and also from the mouth, pharynx, and bronchi. Being exceedingly light, they float in the air, and are inhaled, lodging in the throat, trachea, and even deep in the lungs. It is not pleasant to contemplate the fact that

* "Infant Feeding," Part IV, chapter iv.

we inhale minute portions of each other's bodies, but it is true nevertheless. In diphtheria, scarlatina, small-pox, measles, etc., these epithelial scales come off in vastly greater quantities than in health, carrying with them, in greater or less virulence, the peculiar infection in the body whence they have arisen. The greater their number and the more favorable the nidus in which they become deposited, the more likely they are to become transplanted as primary centers of infection. Hence it is important to prevent their *accumulation*, as the greater their numbers the greater the probability of their successful transplantation ; and as they float in the air they follow its currents, and are thus removed by ventilation. Other sources of organic matters are various and numerous, but, with the following exception, of little importance in the present connection.

The cutaneous surface and the lungs give out certain odors, *sui generis*, which are designated "animal exhalations." It is to these that the heavy, sickening smell noticed on first entering a crowded room is due. Odors being volatile and exceedingly light, these exhalations rise to the highest portions of the room ; and, if not allowed to escape, accumulate there, saturating the air from above downward, and finally reaching the floor. Of all the noxious matters in the fouled air of a poorly ventilated school or public building, these are at once the most perceptible, the most offensive, and the most rapidly prostrating. They produce a sensation of stifling by their irritation of the branches of the pneumogastric nerve distributed to the lungs and larynx, and nauseate, probably by reflex action, through branches of the same nerve distributed to the stomach. A distinguished physician, writing of an infant nursery under his charge where the children did not thrive, and many died of diseases of the digestive organs, says: "One remarkable circumstance observed was that there was a faint odor always present in the room. Yet it was a large room, about fifty feet in length. One side of the room was made up of windows which went up about ten feet where the roof or ceiling beveled up in an inverted ∧ shape, which raised the room in the center seven or eight feet more. Do what I would, I could not get rid of this smell. One day, being much annoyed thereat, I procured some long steps which extended about three feet above the upper ledge of the windows. On walking up, no sooner had I got my head one foot above their level, than I found a terrible odor that made me feel giddy and sick ; and I was glad enough to come down. I instantly sent for a workman, and desired him to remove three or four tiles at each end of the room, on a level with the highest point of the roof. He did so. In ten minutes all odor had disappeared ; but his work was no sooner ended than he was taken very giddy and practically sick, so completely had he been overcome by the pestilential atmosphere." This incident will again be referred to in speaking of ventilators.

In regard to the moisture of the air, the following may be said :

The drier the air, the more rapidly are the liquids of the body evaporated, and digestion and assimilation carried on, the more nervous is the temperament, and the more rapid the development. Generally speaking, the air is much drier in the United States than in Europe. This is the chief reason why our children are less repressible, livelier, and more nervous and precocious than those of Europe. Another reason is, that we use here more animal food, which is far more stimulating both to body and mind than vegetable. On the other hand, too dry an atmosphere is unhealthy. As children drink much water, they exhale much aqueous vapor—the sweat-glands and capillary circulation being more active than in the adult—say to the amount of half a pint each, more or less, during school-hours. As such a large amount of invisible vapor arises, it serves a useful purpose by adding to the moisture of our dry air, rather than being injurious. In dwellings it is sometimes customary to place a vessel of water upon the stove to produce vapor, so as to diminish the dryness of the air; but, for the reason given above, it is perhaps unnecessary in a school-room. However, as water absorbs equal volumes of carbonic-acid gas, and four hundred and thirty volumes of ammonia, a shallow vessel of water may in this way be of some service.

The inorganic matters consist of chalk-dust, earth-dust, ashes, etc. Of late years, owing to the large amount of blackboard work done in schools, particularly in the primary departments, chalk-dust floats in large quantities in the air whenever the erasers are used. The particles of chalk-dust are comparatively large in size. When inhaled, it lodges in the posterior portion of the nasal passages and upper portion of the larynx; and when settled in large amount in these locations it gives rise to a good deal of irritation. The effect of this irritation is the secretion of a tenacious mucus that provokes distressing cough and unpleasant hawking. It is easy to understand how this exciting cause, long continued, may produce a chronic catarrh of these regions, especially in the posterior nasal passages, as they are prone to congestion and a low grade of chronic inflammation. The same remarks apply, but in a far less degree, to ash and earth-dust. The frequent cough and occasional sneeze heard among the audience in theatre, hall, or church, are provoked by the inhalation of fine dust suspended in the air, and might be prevented by careful sweeping and dusting after occupancy. The school-room should be swept every evening, and dusted at least an hour before opening. The blackboards should be erased as little as possible, and preferably by the so-called "dustless" erasers—though, strictly speaking, no eraser is really "dustless," being simply "less dusty"—and then gently in an up-and-down direction, so that the dust may not be dispersed through the room. The floor should not be disturbed by sweeping at any time during the day. Having examined briefly the different substances that vitiate or foul the air contained in a school-room, and the sources from which they

are derived, the means of effecting their removal therefrom will next be discussed.

The chief factors in carrying on ventilation are (*a*) the difference in temperature between the outside air and that within the room, and (*b*) the diffusibility of gases.

It is the difference *in temperature* that produces a draught up a flue or chimney when a fire is lighted below; for the products of combustion have a very much higher temperature (several hundred degrees Fahr.) than the surrounding atmosphere. Being so much warmer, they are lighter in consequence (as will be explained presently), and therefore have a constant tendency to ascend—being compelled by the force of gravity—till, after cooling little by little, they reach a layer of their own temperature. Upon the same principle an inflated balloon ascends and a cork immersed in water constantly tends to rise to the surface. As the coefficient of expansion for gases equals about $\frac{1}{273}$—i. e., they increase about $\frac{1}{273}$ of their bulk for every degree centigrade increase in temperature, *thus becoming lighter in proportion to their volume*, and, becoming lighter (some being originally lighter) than the atmosphere, are compelled by gravitation to ascend. It is important that the pipe or flue, in rooms heated by stoves or grates, should be vertical or nearly so; also that it be not too wide, otherwise downward currents will be produced, and these interfere with the draught, and cause the gases of combustion to escape into the room. In a stove-pipe the elbows should be as few in number as possible, and rounded rather than acute; for a sharp or abrupt bend materially diminishes the velocity of the draught. Two or more pipes opening into the same chimney should have *separate flues;* when they open into the same flue, the pipe that draws best will interfere with the draught in the others, and set up downward currents.

The air consumed by combustion escapes by the chimney, and tends to create a vacuum in the room; but it is steadily replaced by the atmosphere which rushes in at every available opening. This rush is strongest at the lowest openings (those nearest the earth), and here the whole amount enters if the space is sufficient. On the other hand, and for the reasons before given, the warmer (lighter) and fouled air within has a constant tendency to escape at the highest points; and it is here, therefore, that ventilators should be placed to allow its exit. Thus it is that, when a door is opened, the warmer (foul) air escapes in a current at the top, and the colder (fresh) from the outside rushes in at the bottom. This may be shown by a lighted taper held in these situations—the flame in each case taking the direction of the current. When the outside air is the warmer, and per consequence the lighter, as on a very warm summer day, the direction of the currents, other things being the same, will be reversed—the fresh air coming in above, and the cool air within escaping below. But, owing to the large amount of heat radiated from the pupils—the normal temperature of

the human body averaging 37·5° Cent., or 99° Fahr.—the lighter air is nearly always within. Therefore, if on the sheltered side a window is lowered at the top, or on any side if the air be calm, the foul air will escape above it; if raised from below, fresh air will enter beneath. But ordinarily it is sufficient to fully provide for the escape of the fouled air—the fresh, as a rule, will not need so much attention; yet it is better to make ample provision also for this. The best method is by ventilators in the walls—say of a foot square in section, or thereabout—raised but a few inches above the floor below, and lowered but a few inches below the ceiling above; or otherwise at the highest points of the ceiling itself. In this way the currents that are likely to blow on the children's shoulders when the windows are raised are avoided, a matter of importance; for a draught of cold air, blowing upon the shoulders *from behind*, arrests the action of the skin—probably through the spinal sensory nerves—and causes what is commonly known as a "cold." Even when windows are lowered at the top, draughts will occasionally blow upon the pupils; and, the lower the windows are set in the wall, the stronger and more uncomfortable and injurious is the draught. In order to prevent these draughts, the windows should be set high in the wall and lowered on the sheltered side whenever possible. An ingenious contrivance for the prevention of draughts through open windows has been suggested by Dr. Swinburne, in a paper read before the last annual meeting of the New York State Medical Society. It consists in the attachment of one end of a strip of unstarched muslin to a spring roller fastened to the casement above, and the other end to the upper edge of the window itself. On lowering the window, the muslin is unrolled, and thus stretches across the vacant space. Being held tense by the spring of the roller, it effectually shuts off all draught, while it allows the escape of the foul gases within, and the slow but steady entrance of fresh air.

Even should there be no currents through ventilators or open windows, yet the foul gases will make their escape by *diffusion;* for, according to the law of diffusion, there is a rapid interchange between gases in free communication. Of course, the outflow of the inside air very materially hastens the rapidity of the interchange; but the outflow will not, can not, be very rapid if there is not sufficient provision for the entrance of fresh air other than through the same apertures through which the outflow itself takes place. Again, the warmer the day, the less the difference between the temperature of the inside and the outside air; hence the buoyancy of the inside air is less, and consequently the ventilation not so effective; so that more attention and greater facilities must be afforded it. Ventilators should never be placed in the hall; here they do but little good. The doors leading from the hall to the rooms are usually closed, and, even if open, the buoyancy of the air as a factor in ventilation is nearly eliminated; for there is a partition between the hall and the room, so that the light-

air and the lighter animal exhalations would be compelled to descend to the level of the top of the communicating door in order to escape. This they can not do, for it is in opposition to gravity. If no other outlet is provided, the only ventilation will be by diffusion through the doorway with the purer air in the hall. The animal exhalations will fill the room from the ceiling to the level of the top of the communicating door, and there remain. It would cost but a trifle to have one or two ventilators put in the ceiling of a school-room where there are none in the walls; and school directors could not make a better investment of the money. Children will not study, and can not be persuaded or compelled to study diligently, in the foul and stifling air of a crowded and wretchedly ventilated room. It may be safely asserted that in a majority of our schools the ventilation is insufficient, or not properly attended to, either on account of lack of knowledge or attention on the part of the teacher, or the defective construction of the building. A sanitary inspection should be made of every school in the State by a competent medical inspector; and all the schools found defective in this (or any other way injurious to health) should have all such defects remedied, or otherwise be condemned as unfit for school purposes, with the imposition of penalties for using them as such.

A school-room should have a high ceiling; contain from two hundred to three hundred cubic feet of air to each pupil; have one or more ventilators in the ceiling, or the walls near the ceiling; have long, high windows arranged to slide upward from beneath, and downward from above. All the children should be sent out at recess, if only for a short time, in order to have their clothing—saturated as it usually is by animal exhalations—exposed to the purifying influence of the open air, and doors and windows thrown open in order to completely change the air within. Stoves, chimneys, pipes, etc., should be carefully looked after, and any accident or defect promptly attended to, or immediately reported. Children convalescing from contagious diseases should be excluded from school for weeks, or months, according to the recognized limit of contagiousness of the disease. It should not be forgotten that the school and the church are the two great centers for the communication of contagious diseases; and that both are active in this way in direct proportion to the insufficiency of the ventilation.

ORIGIN AND USES OF ASPHALT.

By LEON MALO, C. E.

BITUMEN appears in nature as an accidental mineralogical product, under the most diverse and often most inexplicable conditions. It is found sometimes in the native state, sometimes mixed with clays, sometimes as the cement of conglomerates, sometimes im-

pregnating limestones. The last combination produces the mineral commonly called asphalt. When the bitumen contained in any of these substances is chemically isolated, it appears always a nearly identical substance, in composition, consistency, and appearance, except that the empyreumatic odor that characterizes it may become alliaceous in volcanic countries. Asphalt is doubtless one of the most considerable and valuable of the forms in which bitumen appears. It is a soft limestone, naturally and closely impregnated with that substance. When a specimen of it is examined under the microscope, each grain of it appears to be immersed in a pellicle of pure bitumen, by which it is cemented to the adjoining particles. It is thus a species of very fine-grained bituminous conglomerate. When a lump of this rock is heated to a temperature rising from 176° to 212°, the pellicle of bitumen is melted, the cohesion of the asphalt is destroyed, and it crumbles into dust. If it is taken while it is still hot, or if it is heated again after it has become cool, and strongly compressed, the particles will adhere again, and the stone will recover, after cooling, precisely the consistency and appearance it had originally. The employment of compressed asphalt for pavements is founded on this property.

Asphalt, or bituminous limestone, is generally found in the Jurassic strata, in regular beds of a lenticular shape, which are uniformly cut in two by a stream of water. Sometimes the bed is single, at other times it is multiple ; there are formations containing seven beds, one above the other, and distinctly separated by strata of white limestone.

Different views prevail respecting the origin of asphalt and the circumstances under which it is formed. Some believe that the bitumen was already in existence when the calcareous formation took place, and that the particles of limestone were deposited in a bituminous sea. Others consider that the bituminous matter is derived from the organic matter associated with the shells that have furnished the carbonate of lime ; and other more hazardous hypotheses have been advanced. A careful observation of asphaltic formations has led me to adopt what appears to me to be a more plausible theory.

It is permitted to suppose, from indications furnished by the study of bituminous districts, that in some geological epochs, which have yet been only imperfectly determined, accumulations of organic matter, buried under enormous masses of Jurassic limestone, and heated by the central fire, became vaporized, and in that condition sought a passage through the crust of the earth (Fig. 1). In time the crust cracked, and a fissure was formed. The bituminous vapors, compressed by incalculable pressure, forced themselves through the way that was opened to them, and passed by such strata as were too compact to be penetrated ; but, when they reached the oölite, they found on either side of the fissure beds of a limestone soft enough to admit of their impregnating it (Fig. 2). As long as the pressure lasted, the bitumen con-

tinued to insinuate itself through the pores of the limestone, and to fill its infinitesimal cavities.

Mineral asphalt is relatively a soft stone. It becomes more compact as the temperature diminishes, but yields under the influence of

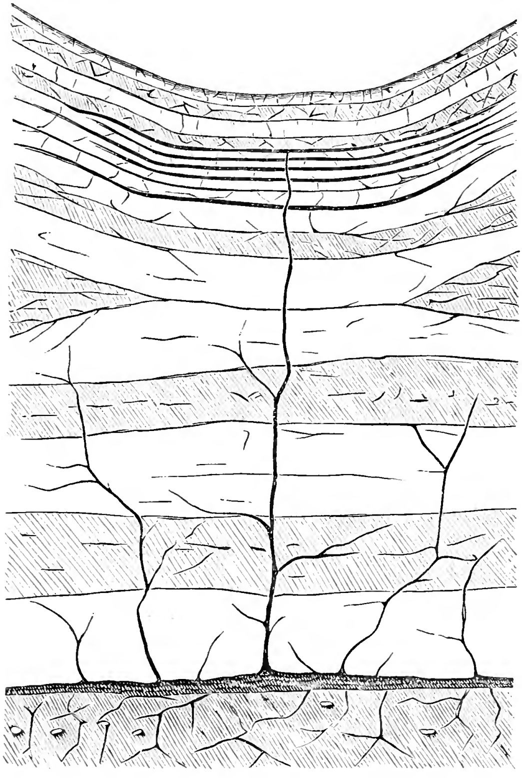


FIG. 1.—PROBABLE FORMATION OF ASPHALT BEFORE EROSION.

heat to such a degree that an exposure of a few days to the summer sun will sometimes cause it to crumble. This property has induced the application of the compressed material to the making of pavements. Its fitness for this purpose seems to have been suggested by accident. When the mineral was first quarried, the pieces which fell along the road from the wagons carrying it were ground up by the wheels, and were finally compressed again by the continued passage of the wagons over the dust, so as to form a kind of spontaneous pavement. A Swiss engineer, M. Mérian, acting upon the suggestion of this incident, asphalted a part of the road from Travers to Pontarlier, in a rough way, but with a satisfactory result. In the next year (1850), M. Darcy, inspector-general of bridges and highways, recommended asphalt as a material for pavements in a report to the Minister of Public Works. The first asphaltic pavement was laid in Paris in 1854.

The mineral appears in industry, under a still more useful form than the compressed form, as asphaltic mastic. This is made by throwing the powdered mineral into a bath of seven or eight per cent. of its weight of liquid bitumen, and mixing the whole thoroughly while it is cooked for five or six hours. The substance produced, although

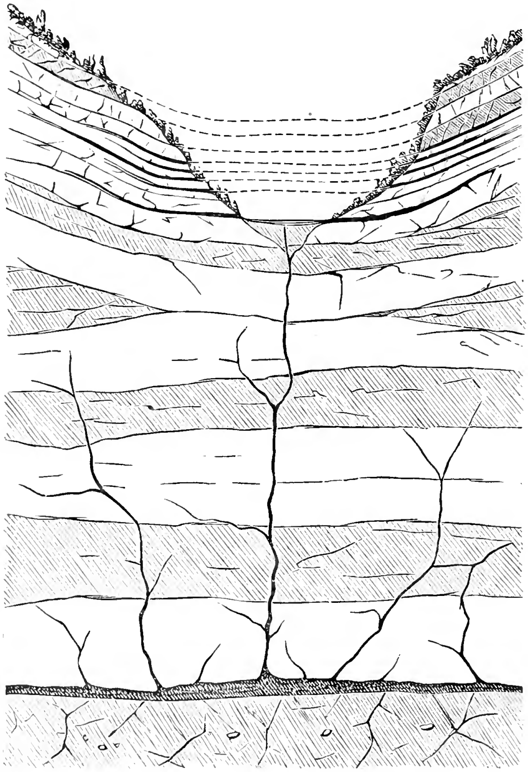


Fig. 2.—Probable Formation of Asphalt after Erosion.

chemically the same, except for the difference in the relative proportions of bitumen and limestone, is physically entirely different from asphalt. It can not be pulverized by heating, but forms a paste in which the two ingredients seem to be perfectly combined, and which may be molded into desired forms. The manufacture of the mastic has become an important industry. The annual production of the French shops alone must amount to fifteen or twenty thousand tons.

In "La Nature," of April 9th, Mr. A. Woeikofen, of St. Petersburg, describes the asphaltic beds of Russia, which occur on the grand curve of the Volga, or the arc of Samara, a short distance above the city of Syzran. They are not deposited in the Jurassic formation, as are those in France, Switzerland, and Germany, but in a dolomitic limestone of the lower Carboniferous series. The mineral is rich in bitumen, of

less fusible quality than the bitumens of France and Switzerland, and has not been produced in the compressed form. It is extensively made into mastic, the fabrication of which already amounts to ten thousand tons a year, and is rapidly increasing.—*La Nature.*

THE UNIT IN PLANT-LIFE.

By BYRON D. HALSTED, Sc. D.

MAN, being himself distinctly individualized, endeavors to find the unit of existence in all other forms of life. He meets with no great difficulties among the higher animals, but is perplexed and sometimes discouraged when search is made for the individual in the lower animals and in plants.

A child is an easily-recognized unit of life at its birth, and is no more than a single individual when it has reached mature middle life, or the decline and decay of old age. A limb may have been lost on the field of battle, or an eye removed by a surgeon, but there is no replacement of the lost parts. The human individual may suffer division, but it is a mutilation, and not a multiplication of the living unit.

In some respects the seed of a plant is analogous to the young of the higher animals; it is the result of a sexual union and the starting-point of a continuation of the species. For these and other reasons the seed may be, and has been, called the unit of life in the higher plants. But what possibilities are contained within the coats of a single seed when the proper conditions for its growth and propagation are secured! When we look beyond the dry and inactive seed, which can be held upon the tip of the little finger, and note what it may produce; when we know that such a single seed has been the starting-point of a variety of fruit that now has its representatives as full-grown trees in thousands of orchards all through this broad land, we must either expand our idea of a plant-unit until it is too great and comprehensive to be of service, or seek some other basis of individuality than that which is in some respects analogous to the accepted one among the higher animals. The idea of the identity of the individual among the more complex and perfect forms of existence in the two kingdoms of life may be dismissed, because the methods of propagation in the two are far from the same.

If we take some common plant of the higher orders—any tree or shrub, or even a herb—it will be found, upon careful study of its structure, that there is an almost monotonous repetition of parts. It will also be observed that these parts may be grouped under three heads, to which the common names of *root*, *stem*, and *leaf* are applied. The root includes that portion of the plant, whether aërial or subter-

ranean, the young growing extremities of which are protected by a layer of tissue called the root-cap. The stem is the axis of the plant, and is the part which bears the leaves, and includes those peculiar growths, such as thorns, runners, tendrils, etc., which serve a special purpose in the plant economy. The leaf is a lateral outgrowth from the stem, and is usually a flat, green expansion, but may assume the form of scales, highly-colored and strangely-shaped floral parts, etc. The fact that the largest tree and the smallest herb are alike made up of a greater or less number of *these plant-members*, as they are termed, leads naturally to the thought that any mass of plant-tissue having a root, a stem, and a leaf, may be a plant individual, and that, when a number of these members are intimately associated together, a *community* of plant individuals is formed. This is the modern conception of a tree or shrub—a living structure, which is the result of the combined, harmonious, silent working of many generations of individuals. Out of the three members are made all the multiplicity of forms and structures which meet our eyes as we look upon the higher forms of vegetation. They all have a common origin in the apical growing-points, and are indistinguishable in their earlier stages, but become differentiated as they develop, and at last assume their characteristic, mature forms. The growing-point of a stem (*punctum vegetationis*) is a conical apex, a little below which the leaves appear first as very slight swellings. By their more rapid growth than the stem, they reach above the growing-point, and, folding over each other, cover it more or less completely. As the stem elongates, the leaves upon the older portion are gradually separated, and an ordinary stem, with its leaves arranged at regular intervals, results. A bud is simply a young stem, with its undeveloped leaves. A developed stem is a series of similar parts, those parts being a leaf with a portion of the stem above and below it, each borne upon its predecessor, and in turn bearing the next one in the series. These similar parts have received the name *phyton*, and are very generally considered as the individuals out of which a plant community is built up. The gardener divides the young branches of the verbena, salvia, etc., into these phytons, and places them in moist sand, where they soon begin an independent existence, and in time reproduce their kind. In the operation of grafting, a similar portion of a plant community of one variety is given a fitting place for growth in another, and by its growth and multiplication of phytons a new colony is established. With this view a tree or shrub may form an *individual* part of a landscape, but not in the same sense that one may speak of a cow or a horse. The tree more nearly resembles a swarm of bees; there is a similarity of unity between a shrub and a hive. The larger part of the shrub is made up of foliar units, with ordinary leaves for the elaboration—gathering, so to speak, of the food for the whole community. These are the *workers* and the *neuters* of the vegetable "hive." Other plant

individuals devote their energies to the production of new plant-units, namely, the stamens—the male units of the flowers—which perish as soon as their transient but important work of fertilizing the pistil is accomplished; these are the *drones*. The pistil is the central part of the flower, and around which all the work of propagation converges and the labors of the year culminate, and from which the new individuals, the seeds, go forth to develop into free and independent colonies. In several respects this pistil is *queen* of the congregated vegetable units.

There are some objections to the phytons being considered the unit of vegetable life. The division of a plant may be carried beyond it, and life and growth of the parts still be maintained. Thus buds may arise from petioles, or leaf-stalks, and from the veins of the leaf, as in the ordinary propagation of the begonia, and very strikingly in the bryophyllum. Buds may start from the woody bundles of roots, as in the sweet-potato, poplar, or the cut stems of the elm, willow, etc. These many cases of a seemingly spontaneous growth have led to another definition of the plant-unit which is formulated briefly as follows: A plant individual is that smallest part that can grow when separated from its former place in a plant community, and given the fitting conditions for growth by itself. In most cases this "smallest part" is the phyton, or a portion of the stem with its leaf, and the bud or growing point which it bears in its axil. This young lateral bud, which is frequently so small as to be unseen by the naked eye, is, in fact, the vitalized, undeveloped stem that is to increase in size if growth takes place. The writer is of the belief that in this growing-point the individuality of higher plants should be located. If there are two buds upon the phyton, it seems proper to say there are two individuals, as there are two distinct points of growth, and two branches may result therefrom.

If the phyton is to be considered as the plant-unit, we must seek for another unit of life for those plants in which no phyton elements exist. The unit of growth is the cell; in it, either alone or in connection with other cells, all the functions of life are performed. Cells compose the growing tissue of every plant; in them resides that vitalized substance called protoplasm, in which all life-changes take place, and from which all structures are built up.

Many of the lower plants are unicellular, as, for example, the common yeast-plant, bacteria, etc., among fungi, and the desmids and diatoms among algæ. They increase in number by a simple division of the cell into two, each half increasing in size and dividing as did its parent. The individual among such plants is evidently the single cell. As we pass a little higher in the scale of vegetable life, it is found that though the cells are associated together in filaments, or laminæ, they are, in most respects, very independent, losing only a trifle of their originality by being associated in the simplest form of a com-

munity. As we pass upward in the scale, the differentiation increases, and there is a consequent division of labor, some of the cells being devoted to one kind of work, while others engage in a special labor for the community. Instead of the sum of the vital forces possessed by an individual being confined to a single cell, they are scattered through a large amount of growing tissue.

The seat of vitality is protoplasm, and wherever there is enough of this vitalized substance to grow and reproduce its kind, there we have an individual—a unit of life. It may be concentrated in a single cell, or distributed through many cells, the number and distribution being determined by the amount of dependence of the growing cells upon each other. The greater the division of labor, the higher the form of life, and the more difficult to recognize the individual; but, whenever it is found, it consists of a mass of protoplasm, usually contained in one or more cells, capable of growth under proper conditions, and ultimately reproducing its kind.

"THE ELECTRIC STORAGE OF ENERGY."

SOME few weeks ago a letter appeared in the "Times," signed "F. R. S.," describing a "box of lightning" which the writer had brought over from Paris for the purpose of submitting it to Sir William Thomson. Since then a long discussion has taken place on the subject of the invention and its usefulness. To begin with, we fully share the regret of Professor Tyndall, who has written a letter on the matter, that so much loose nomenclature has been introduced into the subject. The term "electric storage of energy" appears to us to be singularly unhappy. What is known as a condenser, or a Leyden-jar, is truly an instrument for the electric storage of energy, because, when charged, its parts are in a condition of molecular strain, which is recognized as an electrical phenomenon; and the release of this state of strain invariably produces at first some of the phenomena of electricity in motion. But in the case of M. Faure's secondary battery, which is the invention under discussion, although it is charged by a current of electricity and gives out a current of electricity, the form of the store of energy which it contains is not that of electrical stress or strain, but that of chemical separation—a form of potential energy which can be caused, under certain circumstances, to become kinetic energy in the form of heat. However, the term has now become established, and, being convenient, will probably survive. But it is to be hoped that the real state of things will be thoroughly and publicly explained by our leaders of science, so that the use of this form of words may not cause a confusion in scientific ideas.

From the ease with which secondary batteries can be constructed of very low resistance, so that they will give for a short time what practical electricians call a quantity current, they have been for some time in use for certain special purposes, principally for heating the wire of the galvanic *écraseur* in surgical practice. By a secondary battery is meant a galvanic battery which, as at first put together, has no tendency to give a current at all; but, if a current of electricity be passed through it of sufficient tension to decompose the fluids which it contains, will give a current in the opposite direction, due to the recombination of the separated parts of the decomposed fluid. The older forms consisted of two plates of platinum, preferably coated with spongy platinum immersed in a weak mixture of sulphuric acid and water, the action in this case being that the charging current decomposes the water (either directly or as the result of a chemical action set up by decomposing the acid first) into oxygen and hydrogen, which gases are absorbed by the platinum plates, the oxygen by one and the hydrogen by the other. When the charging battery is removed, the secondary battery will give a powerful current until all the oxygen and hydrogen absorbed by the plates are recombined in the form of water. It was afterward found that satisfactory results could be got from plates of lead treated in the same way. Their employment, of course, reduced the first cost of the apparatus. M. Planté then produced his secondary battery, in which he obtained great surface, and consequently low internal resistance, and large current, by rolling into a spiral form two lead plates separated by pieces of insulating material placed between them at intervals. He further succeeded in greatly increasing the time for which the battery would yield a given current, or its capacity, by adopting an elaborate process for the "formation" of the plates, which consisted in charging the battery and discharging it, varying the direction of the exciting current, and leaving the battery undisturbed between the charging and discharging for gradually increasing intervals of time. This process added enormously to the expense of the apparatus, which was also too bulky and heavy.

M. Faure, however, has succeeded in increasing the capacity of the battery, and getting rid of the long and delicate process of formation. His battery, like M. Planté's, consists of two plates of lead rolled together into a spiral, but he coats each plate with a thin layer of red-lead (one of the oxides of that metal), kept in its place by a piece of absorbent felt, which also keeps the two plates from touching. This felt is saturated with the weak acid. The effect of the exciting current in this case is to deposit spongy lead on one plate and to convert the red oxide on the other into puce-colored oxide which contains more oxygen than the red form; no doubt, also, the spongy lead at a late period of the charging becomes saturated with hydrogen. When the battery is now set in action, the spongy lead becomes reoxidized to red-lead and the puce-colored oxide reduced to the same salt.

Sir William Thomson early in this month wrote to the "Times," pointing out the great advance which this invention had made in the practical and economical storage of energy. His letter was answered by Professor Osborne Reynolds, who, with the intention of preventing the public from being astonished at the storing of so much energy as one million foot-pounds in apparatus occupying a cubic foot of space and weighing about seventy-two pounds, proceeded—somewhat irrelevantly as we think—to discuss the energy contained in a pound of coal, and also to complicate the now inevitable controversy by referring to a totally different problem, the transmission of energy by electrical means. The controversy thus started has gone on, Sir William Thomson, Professor Osborne Reynolds, Professor Ayrton, and Professor Tyndall, taking part in it.

The question, as far as the public are concerned, is a purely commercial one. As yet, of course, the data of the cost of the battery and its durability are not yet ascertained ; but, in any future discussion on the subject, the question of convenience, as well as that of absolute expense, will have to be taken into consideration. At present we know that, at some expense, probably not too great, we can utilize a source of energy of feeble power for many purposes by allowing it to act for a long time, collecting its energy, and using it quickly, and that the loss in the process will be but small ; and that, further, if it be desired to use the electric light temporarily, it can be produced conveniently, if not economically, by the use of M. Faure's invention. Sir William Thomson in his first letter points out many practical uses for the new invention ; we may supplement them by pointing out how the new secondary battery may be applied conveniently for many purposes. Three ordinary Daniell's cells will charge an element of the new battery easily, so that, if there be plenty of time for preparation, we can, by the aid of Faure's batteries, use this cleanly apparatus, which gives off no noxious fumes and needs but little attention, for all the purposes for which, up to the present time, we were obliged to employ the costly and troublesome Grove's or Bunsen's batteries, which contain violent caustic poisons, and give off irritating and unwholesome fumes.

The whole discussion about the mechanical value of coal seems to us mistaken ; neither Sir William Thomson nor any other physicist proposes to use the new battery universally, and, at present, our cheapest way of charging it is by the use of a dynamo-electric machine, driven by a steam- or gas-engine—i. e., by making use of the mechanical power of coal and the oxygen of the air ; setting aside, of course, the exceptional cases where water-power is to be obtained. Sir William Thomson himself gave, we think, the *coup de grâce* to any attempt at comparing the relative values of transmitting electric currents through conductors from the source of energy to a distant station where energy is wanted, and conveying energy by exciting Faure's

batteries at the one place and conveying them to another, when he wrote in one of his letters of "Professor Reynolds's disappointment with M. Faure's practical realization of electric *storage*, because it does not provide a method of *porterage* superior to conduction through a wire." This is "like being disappointed with an invention of improvements in water-cans and water-reservoirs because the best that can be done in the way of movable water-cans and fixed water-reservoirs will never let the water-carrier supersede water-pipes wherever water-pipes can be laid." If we may venture to extend the great electrician's metaphor, it is like finding fault with the Great Eastern Railway Company's service of sea-water brought to London in cans, on the ground that it is just possible to obtain sea-water by a large main laid down to the coast, and that such a scheme is now under consideration. Another valuable property of the new battery is pointed out by Sir William Thomson. If it were to be used either at a fixed station to work an electric railway, such as the firm of Siemens have already brought into practical use, or to be carried on an ordinary carriage to drive it, the energy developed by the vehicle in running down-hill would be stored up ready to be used for its propulsion when it again reached a level or an ascending incline.

In the course of the correspondence Professor Ayrton has again mentioned the experiments which he and Professor Perry are carrying out with the view of using coal or coal-gas instead of zinc in a primary battery. Should he succeed in doing so, we should obtain a source of energy about ten times cheaper in working than the best-known steam-engine, and M. Faure's invention may very likely be the means of making it a commercial success; for, should Messrs. Ayrton and Perry, or any other physicist, succeed in making a coal or coal-gas battery giving a good proportion of the theoretical energy of the coal or gas, should it have a high internal resistance, it would be difficult to use it in practice; but, by the aid of Faure's batteries, in cases where work was only wanted to be done for a few hours a day, as in the case of electric lighting, the comparatively feeble current of the primary battery might be collected and stored for fifteen or sixteen hours, and then allowed to run out again in the eight or nine hours for which the source of energy is practically wanted.

The subject of this new secondary battery is one of great scientific importance. As the writer of a leader in the "Times" points out, it is by no means unlikely that a similar piece of apparatus may be made of some metal, and its appropriate salt, which shall be cheaper and lighter than one of M. Faure's form of similar powers; at all events, the invention and its results are pretty sure to turn the attention of inventors and investigators toward batteries both secondary and primary—a branch of inquiry which has for so many years been quite thrown aside in favor of endeavors to improve the dynamo-machine. Now, a primary battery is theoretically the most economical artificial source

of energy, and it is only the comparatively high cost of the fuel generally used in these—zinc—which prevents them from being practically useful. A galvanic battery gives out very nearly the whole energy due to the chemical combinations which take place in it; so that it is hardly too much to say that, were a battery to be employed to drive an electro-motor, under suitable conditions, we could obtain at least sixty per cent. of the chemical energy, while the best-known steam-engine will only give about ten per cent. of the chemical energy of the coal and air consumed in its furnace. There is thus a large margin for the first cost of the substance to be consumed in the battery.—*Saturday Review.*

SKETCH OF ROBERT WILHELM BUNSEN.

IT has been given to few scientific investigators to be more closely identified through their discoveries with the practical progress of the world, to see the fruits of their researches taken up and applied, made appreciable and beneficial in a greater diversity of lines, than to Robert Wilhelm Bunsen.

Professor Bunsen was born in Göttingen, March 31, 1811. His father was Professor of Theology, and of the Oriental Languages and Literature, in the University of Göttingen. Having passed through the course of the gymnasium, he entered the university, devoted himself to the study of chemistry and physics, and was graduated as a Doctor of Philosophy in 1830, publishing as his inaugural dissertation, "Enumeratio ac Descriptio Hygrometorum," or, "Enumeration and Description of Hygrometers." He afterward studied in London, Paris, and Vienna, and became, in 1833, tutor at the University of Göttingen; in 1836 he was appointed Professor of Chemistry at the Polytechnic school in Cassel; took the corresponding chair at the University of Marburg in 1838, and remained there thirteen years; then went, in 1851, to Breslau, where he planned a famous working laboratory; and in the next year went to Heidelberg, where he has for thirty years added to the fame of the great university.

His works in his chosen field have been numerous; their value, whether they are measured in relation to the advance of theoretical science, or as factors in the perfection of the operations of practical art, has been very great.

In 1834, in conjunction with Berthold, he published a research upon hydrated peroxide of iron as an antidote to arsenical poison, introducing a remedy which, having become universally known and universally accessible, may be regarded as a positive addition to the security of human life against a certain class of dangers.

He next, in 1835, described some singular compounds which the

double cyanides form with ammonia, and the crystals of many of the double cyanides. In 1837 he began a series of investigations of the liquid called Cadet's fuming arsenical liquid—the product of heating a mixture of acetate of potash and white arsenic, discovered in 1760—and brought out the radicle cacodyl, the first of a series of organo-metallic compounds which exhibit striking analogies with the metals. These bodies are unpleasant in every way, extremely poisonous, dangerously explosive, highly inflammable, and often, like cacodyl, insufferably offensive in odor. "It is difficult enough nowadays," says Professor Roscoe, in "Nature," "for a chemist to work with such substances, armed as he is with a knowledge of the danger which he has to encounter, as also with improved appliances of every kind to assist him in overcoming his difficulties. But Bunsen, forty years ago, was a traveler in an unknown and treacherous land, without sign-posts to guide him, or more assistance on his journey than was furnished by his own scientific acumen and his unfaltering determination. Nor did he escape scot-free from such a labor, for, in analyzing the cyanide of cacodyl, the combustion-tube exploded, Bunsen lost the sight of an eye, and for weeks lay between life and death, owing to the combined effects of the explosion and the poisonous nature of the vapor. 'This substance,' he writes, 'is extraordinarily poisonous, and for this reason its preparation and purification can only be carried on in the open air; indeed, under these circumstances, it is necessary for the operator to breathe through a long open tube so as to insure the inspiration of air free from impregnation with any trace of the vapor of this very volatile compound. If only a few grains of this substance be allowed to evaporate in a room at the ordinary temperature, the effect upon any one inspiring the air is that of sudden giddiness and insensibility, amounting to complete unconsciousness.'"

His next research, published in 1838, was into the chemical changes which occur in the blast-furnace. In it he showed that at least forty-two per cent. of the heat evolved from the fuel employed in the furnace was lost, and pointed out that a great economy might be effected by collecting the combustible gases which escaped, and saving them for subsequent use. The investigation led to the introduction of improved methods by which the waste gases were utilized, and the cost of the manufacture of iron was cheapened. The experiments made in this research were the first in which an accurate method of gas-analysis was employed, and entitle Bunsen to the credit of having introduced new and valuable processes in that line to chemistry.

In 1841 he invented the Bunsen battery, an apparatus which has come into general use as a scientific instrument, and in telegraphy. Its chief peculiarity is the substitution of carbon for copper or platinum as the negative pole.

He visited Iceland in 1846–'47, and devoted special attention to the study of the volcanic phenomena of the island, particularly of the

geysers. The memoirs which he published on the subjects of these studies contain the analyses of the volcanic rocks occurring in the island, which led him to the theory that all the eruptive rocks that reach the surface consist either of an acid or a basic silicate, or a mixture of the two, that has been formed and crystallized within the interior of the earth. Other papers relate to the formation of various crystalline minerals by the joint action of heat, acid gases, and moisture, on the rocks, and the theory of the geysers.

With the aid of his battery, Bunsen performed the electrolysis of some of the rarer metals. He began with magnesium, which he prevented from taking fire as soon as it came to the surface by the ingenious device of catching the metal as it rose in a cup, which he formed in his carbon pole for the purpose, while it was still under the salt. He then proceeded to the reduction, in conjunction with the late Dr. Matthiessen, of the alkaline-earth metals, and, with Hillebrand and Norton, of the metals of the cerium group. Applying metallic magnesium in photo-chemical researches and in comparison of the light of its flame with that of the sun, he gave the impulse which induced the undertaking of the commercial preparation of the metal.

Other researches, with which his name is connected, are those of Kolbe on the electrolysis of the fatty acids, of Kolbe and Frankland on the isolation of the organic radicals, the explanation of a new method of determining vapor densities, the investigation and correction of Dalton and Henry's law of absorption of gases in water, experiments on laws of gaseous diffusion, on applications of gaseous diffusion in gasometric analysis, on the phenomena of the combustion of gases, and on the temperature of ignition of gases; all of which were performed by himself or his pupils, or both.

In analytical chemistry Bunsen has contributed something valuable to the solution of nearly every important problem, and the best methods in complicated laboratory processes like those of the analysis of silicates and mineral waters, methods for the estimation of nitrogen and sulphur, and a method of volumetric analysis, which, though requiring considerable time for its completion, leaves little to be desired in point of accuracy and simplicity of manipulation. He introduced a general method for the separation of the rare earths, by which he for the first time prepared pure yttria and erbia, and by which several new metals have been discovered by other chemists.

In connection with his investigations on the measurements of the chemical action of light, Professor Roscoe, who was associated with him, speaks admiringly of his untiring energy and wonderful manipulative power, and says that, in all the difficulties and perplexities by which the experimental investigation of such a subject is beset, he never knew Bunsen discouraged, or at a loss for an expedient by which an obstacle could be overcome. "Cheerful and self-reliant under the most depressing circumstances, he never gave up hope, and thus it was

that these somewhat intricate and difficult investigations were brought to a successful close."

Perhaps none of his labors are more distinguished than the experiments with which he and Kirchhoff laid the foundation of the new science of spectrum analysis. Among his own most important transactions in this work was the discovery, by means of the spectrum lines, of the metals cæsium and rubidium. He first saw the cæsium lines, says Professor Roscoe, in a few milligrammes of the alkaline residue obtained in an analysis of the Dürkheim mineral waters, and the discovery of a second new metal (rubidium) soon followed that of the first. "So certain was he of the truth of his spectroscopic test, that he at once set to work to evaporate forty tons of the water, and with 16·5 grammes of the mixed chlorides of the two new metals which he thus obtained he separated the one metal from the other (no easy task) and worked out completely their chemical relationship and analogies; so much so, that the labors of subsequent experimenters have done little more than confirm and extend his observations." Another research in this direction was that on the spark spectra of the metals contained in cerite and other rare minerals, which he carefully mapped in such a manner as to make the separation and identification possible.

Bunsen's name is identified with two instruments which he has devised, which have come into general use in science and the arts; the Bunsen gas-burner, which is almost indispensable in laboratories and in many processes of manufacturing, and is used in many households; and the Bunsen pump for accelerating filtration, which those who employ it could likewise hardly do without.

His published writings are many. Most of them are special papers relating to the subjects of investigation that have been already mentioned; others embody more general results of his studies. His visit to Iceland gave rise to several papers on the various physical, geological, and volcanic phenomena of the island; his studies in metals to a number of monographs; his spectroscopic studies to "Chemical Analysis based on Observations of the Spectrum," published by him and Kirchhoff. Besides these, we may mention "Researches on Chemical Affinity"; "On a New Volumetric Method"; and "A Treatise on Gas Analysis."

Concluding his notice in "Nature," from which we have drawn liberally in the preparation of this article, Professor Roscoe says: "The many hundreds of pupils who, during the last half-century, have been benefited by personal contact with Bunsen will all agree that as a teacher he is without an equal. Those who enjoy his private friendship regard him with still warmer feelings of affectionate reverence. All feel that to have known Bunsen is to have known one of the truest and noblest-hearted of men."

CORRESPONDENCE.

THE PHENOMENA OF SPOUTING SPRINGS.

Messrs. Editors.

DEAR SIRS: On pages 28 and 29 of the May number of the "Monthly" there is given an explanation of the fact that some of the Saratoga springs spout intermittently, which seems to be entirely inadequate.

The author says: "As the water flows into the pocket from the surrounding inlets it gradually rises above the outlet, which results in the compression of the gas between the roof of the cavity and the surface of the accumulating water; when the force of compression reaches its maximum, it drives the water from the chamber up through the tube, from which it escapes in some instances to a distance of thirty feet in a vertical direction. After the pent-up water and gas have escaped, the spouting ceases," etc. There is nothing in the explanation or the diagram referred to in connection with it that would warrant the conclusion that gas thus pent up would relieve itself of pressure with a suddenness sufficient to produce the spouting. On the contrary, the flow of the spring, under the conditions stated, ought to be very uniform instead of intermittent. If the inflowing water "gradually rises above the outlet," the gas in the upper portion of the pocket would be as gradually compressed, and its reaction upon the water would tend, precisely like that of the air in the air-chamber of the common force-pump, to steady the outflowing stream and to prevent spouting. Very respectfully,

G. H. COLTON.

HIRAM, OHIO, *May* 9, 1881.

CONTROL OF PAIN BY MECHANICAL VIBRATIONS.

Messrs. Editors.

As the article entitled "Mechanical Vibration as a Remedy in Neuralgia," in the Miscellany Department of the June number of "The Popular Science Monthly," is likely to elicit further inquiry, on account of the wellnigh universal interest in the conclusions set forth, I may be pardoned for offering a few facts pertinent to the same subject.

The control of neuralgia, and indeed of pain in almost any chronic form, by mechanical vibration, as asserted by M. Boudet de Paris and Dr. Granville, has been so thoroughly demonstrated as no longer to admit of question, and should be considered as well settled as any principle in medicine. Nor is the control of this agent over the nerves limited to pathological conditions. It is an anæsthetic as powerful as simple. Under its influence I have repeatedly witnessed such injury to the skin and flesh as would ordinarily produce unbearable pain, without in the least affecting the consciousness of the subject of the experiment. Indeed, so complete may the anæsthetic effect be made, that I have no doubt, were it possible to secure other mechanical conditions necessary, the capital operations of surgery might be painlessly performed under its influence. The same agent is also efficacious in removing obstinate insomnia.

The essential facts presented by M. Boudet de Paris and Dr. Granville, especially those relating to therapeutics, were given by the writer in considerable detail, in the "New York Medical Journal" (Appletons'), about ten years ago. These were then presented as the result of several years of experimenting with the agency in question, to determine the forms of apparatus required (which was found to admit of considerable variety, providing only that due rapidity of motion and shortness of stroke were preserved), and the efforts of varied methods of application in different pathological conditions of the nervous system. These articles were afterward published in book form, entitled "Paralysis and other Affections of the Nerves, and their Cure by Transmitted Energy."

The hypothesis of M. Boudet de Paris, that abnormal vibrations of the neuralgic nerve are opposed and annulled by mechanical vibrations, seems to imply a fixed rate for each of the differing conditions. In practice, it is found that the removal of pain is progressive, and the anæsthetic effect increases with increase of rate of mechanical vibration — which appears unfavorable to this hypothesis.

The efficacy of mechanical vibration to abolish pain may probably be explained on physiological grounds easily understood by all. For the application of this agent is in reality a supply of energy, which is immediately transformed into and merges with preëxisting physical operations of the vital system—of course, aiding to perfect these actions. No portion of such transmitted energy is lost—it only changes its form—and reappears in increase of temperature,

in motion of contents of obstructed capillaries, and a general rise of all physical operations to the normal degree. Congestion is as certainly removed as water from a sponge under pressure of the hand.

Among these intermediate effects of transmitted energy, the most certain and striking in a therapeutic view are *oxidation*, and what I will venture to call *functional revulsion.* The evidences of immediate and very great increase of oxidation in the living body superinduced by mechanical vibration are abundant and indisputable. The effect is, that the toxic principles incident to retained waste, in which the suffering nerves are bathed, are destroyed, certainly and quickly.

Functional revulsion is no less positive, and may be understood in this way. Like normal feeling, pain is entirely dependent for its existence on nutritive support; in fact, is *more* dependent. Such support during pain is, of course, excessive. To abolish pain, nothing more is required than to withdraw its support.

Now, the muscular masses entering into the composition of the body are, say, forty times that of the nervous masses; the latter are normally the incentives of the former to action, and therefore to nutrition. When nutritive action is incited in the combined mass, as it certainly is by mechanical vibration, it follows that the muscular portion receives the benefit overwhelmingly, both because of its immensely greater mass, and because it is *involuntary.* The function of the nerves, therefore pain, is suspended.

George H. Taylor, M. D.

EDITOR'S TABLE.

SELF-GOVERNMENT IN EDUCATION.

HE who said that the key to the government of mankind is given in the three words "hell and bayonets," made a compact formula for that system of external coercion by which human conduct in past times has been chiefly regulated. Men have been ruled through their fears and by intimidation, the state threatening the penalties of this world, and the Church those of the next, to enforce conformity to the prescribed standards of right conduct.

And there must be external compulsion, if there is no other. Men have to be dealt with according to their natures, and where these are low and brutalized they must be coerced by coarse and brutal methods. But social experience slowly develops the better traits of character, so that men become amenable to the influence of higher motives. In what we call the progress of society, external constraint gradually gives way and men learn more and more to govern themselves. Evolution here as elsewhere is by substitution. The progress of human freedom consists not in escape from restraint, but in the exchange of lower for higher restraints —in the replacement of state-control by self-control.

Unquestionably this is the most fundamental and important change that is going on in society. It is the highest aspect of human progress. It is the growth of the voluntary system, at the expense of the involuntary or compulsory. It is the development of mankind by discipline in the self-regulation of conduct. The transformation of men in this way is a great reality, and gives origin to whatever there is of free or liberal government in the world. All the humanizing influences by which men are ameliorated and improved take final effect in their liberation from external governing forces, so that they become responsible, self-determining agents, and in that sense free and independent.

How educational systems have been and are still related to this great tendency is a very interesting question. It can not be denied that they have had some share in promoting it, but their influence on the whole must be counted as powerfully adverse to it. In fact, school government has been generally modeled on the conception of monarchical government: the teacher has been

a "master," and has ruled his subjects by arbitrary coercion. The rod—the instrument of most degrading punishment—has ever been the symbol of educational control; and, although it begins to be widely seen that it does not represent the better method, thousands of schools are still fighting to maintain it. The schools reflect the general condition of thought, and, if the state is stringently coercive and the people tolerate it, the schools will imitate the policy. Besides, men love the exercise of power, and teachers are no exceptions to this dangerous propensity. External compulsion, moreover, is the simpler and easier way of governing, and, in fact, is all that is left to the teacher without resources. The resort to the rod and kindred measures stamps the teacher with incapacity for his vocation—that is, with an ability to govern by the best methods. Everybody knows that the rod plays no such important part in the work of education as it formerly played. Its sphere has been encroached upon by superior influences. Its stanchest defenders only claim to use it but "sparingly," and the best teachers reject it openly and entirely.

The old system is thus partially outgrown and much discredited; but there has as yet been but little intelligent and adequate effort to organize the method of self-government in its place. The more offensive forms of coercion are abated; but school-government still mainly rests upon external authority, though brought to bear in milder ways. There seems to be still but little recognition of the principle that the essential and supreme work of education is to form character by the cultivation of self-control, which implies liberty and responsibility. And this is not to be learned by precept, but by practice. Self-government, like music, can only be acquired by exercise, and to gain this the school itself must be worked by this method. Students must be thrown back upon themselves, and habituated to responsible self-direction.

As this is the highest result of education, so it is undoubtedly the most difficult of attainment. The grosser forms of punishment may be quite dispensed with, and still the school-goverment may be that of external caretaking and paternal regulation. The model college president has been the man who could know or divine everything that is going on among the students, and circumvent and disconcert them in all their little irregularities. Under this system it has ever been the ambition of the students to beat the faculty, and it naturally engenders a state of antagonism between the students and the governing authorities. Such a system by its very nature must fail to develop the most valuable traits of manhood.

From this general point of view we have taken much interest in the reform of collegiate government which has been attempted during the past year at Amherst. It is reported that President Seelye submitted a new plan to the faculty, that it was adopted, and that the results thus far have been in a high degree satisfactory.

The method consists in placing the student and the college upon an equal footing, and bringing them into relation by a mutual voluntary engagement. A correspondent of the "New York Evening Post" says:

> Every student upon entering college signs an agreement to observe its laws. This agreement is held to be a contract. If it is broken there is an end of the contract, and the contracting parties are as they were before it was formed. The student is no longer a member of the college, and the college owes nothing further to him. . . . The ground taken by the Amherst College government is that the faculty are the helpers of the younger men who want an education. The manhood of the students is recognized, and they are trusted to govern themselves without the interference of the faculty, save when the rupture of the contract compels the separation of a student from college.

At first the students did not grasp the sweeping force of the new laws, and one case of discipline, resulting, however, in a renewal of the broken contract by the student and college authorities, occurred before the idea was firmly fixed that the students were to be a self-governing body as far as their conduct is concerned, and that the only concern of the faculty was the observance of the contract and the retention of the students, or the end of contract relations with them if their promise should be broken.

Since this case, say the faculty, a higher tone has been observable among the students. They are no longer watched; professors do not feel called upon to act as police-officers; there is a freedom and self-accountability not known before, and consequently a better grade of deportment than before. After a student has been informed that he is no longer a member of college because he has broken his promise to obey the college laws, no further attention is paid to him. Should he come to recitations, as he can do, because they are open to visitors, he will be regarded exactly as a visitor. He can leave town or not, just as he chooses, and he can go to another college, as far as any notice from Amherst is to be feared. By the agreement among the colleges, no student could go from one to another without papers showing an honorable dismissal. No student expelled from one could find an open door at the other. Amherst has now withdrawn from that position.

President Seelye has made the following slight correction of the foregoing:

We have not yet relinquished the former prohibition upon the admission of students expelled from other colleges, nor are all who will sign the contract placed on an equal footing and no questions asked; on the contrary, no student is admitted here without a careful inquiry into his antecedents and his standing, nor unless he gives satisfactory evidence that his contract will be kept. We have only relinquished our claim upon the other colleges to help us by their prohibitions in maintaining our discipline.

We regard this experiment as having great significance. It is something to have this evidence of liberal aspiration on the part of college authorities, and it is much to have so prompt an acknowledgment of the salutary results of the reform; but everything is gained when such an institution steps forward and plants itself upon a great principle hitherto regarded as a mere matter of theory. It is more than a change in the form of government; it is an actual transfer of the governing power. Contracts are common things, and it may seem a small matter that a student should make a contract with the college where he proposes to be educated. But the contract is, that he is to govern himself, and voluntarily to square his conduct to the prescribed requirements of the institution. Honor, pride, ambition, are all pledged that he will keep his engagement. It is no small thing for a college quietly and effectually to secure these forces on the side of order, and thus avoid the conflict and antagonism with its students that coercive government naturally engenders; and it is certainly no small thing for the student to take a relation that will involve the constant and vigilant exercise of the most manly traits of character. The college thus becomes in an important sense a school of moral self-culture, a discipline in manhood, and offers the best preparation that can be given for the duties and responsibilities of practical life.

LITERARY NOTICES.

Anthropology: An Introduction to the Study of Man and Civilization. By Edward B. Tylor, D. C. L., F. R. S. With Illustrations. New York: D. Appleton & Co. Pp. 448. Price, $2.

The appearance of Mr. Tylor's long-expected manual of anthropology will be welcomed by many as a valuable contribution to the cause of advancing education. Anthropology, the science of man, is the latest and highest product of growing knowledge. Speculations concerning the nature of man began early, and were mixed up with the loose knowledge that gradually accumulated; but it is only in quite recent times that this knowledge has begun to be winnowed and sifted and verified and classified,

so as to take on something of the scientific form.

There has never been a lack of interest in the subject, and its claims and rank were neatly formulated by the poet, in his celebrated line—

"The proper study of mankind is man,"

long before the proper method of the study was discovered. Anthropological science—that is, the systematic and comprehensive study of the human race by scientific methods—belongs to the last half-century. A great amount of valuable knowledge has been accumulated upon the subject during that time, and digested in many voluminous treatises. But there was wanting a text-book that should sum up the leading facts and fundamental principles of the science in an authoritative and trustworthy manner, and in a form convenient and suitable for general use. Such a work is the one before us.

It need hardly be said that this is no field for the ordinary compiler. He may do useful service in the old sciences, where the subject-matter has been many times elaborated, and the method of exposition long settled; but only a master who knows his subject at first hand, broadly and thoroughly, can be trusted to present so vast a subject, and so rich in new and varied materials, in the due proportions of its parts, and in a compact, well-organized, and authentic form. Mr. Tylor, of all living men, was best prepared to accomplish this task. His elaborate works on "The Early History of Mankind" and on "Primitive Culture" have given him an eminent place as a pioneer and constructive student in the domain of anthropology. He has accordingly been long solicited to prepare a text-book upon this subject, for the use of students in high-schools and colleges, as it has been well understood that this science must soon take a leading and permanent place in the curriculum of a liberal education. The pressure of original studies prevented him from undertaking the work, and has much delayed it, but he has not allowed himself to be unduly hurried, well knowing the difficulty of giving his exposition a satisfactory form within the convenient limits of a handy-volume. But he has fulfilled the utmost expectations, and made his "Anthropology" the one unrivaled book upon that science for general educational purposes.

Of course, the scientific study of "Man and Civilization" can now be pursued only in the light of the doctrine of evolution. It is this law, indeed, that brings the facts of this subject into order, and gives organic method to the science. Anthropology is by no means a mere description of the different races and varieties of men; it deals also with the deeper problems of their transformation from lower to higher conditions, and with the development of all those elements which give rise to the civilized state. This is the underlying conception of the science, and how fundamental it is in the plan of Mr. Tylor's work may be best illustrated by briefly referring to the contents of his successive chapters.

In his first chapter, on "Man, Ancient and Modern," he opens up the new point of view from which man is to be studied. He then proceeds to define and fix the place of man in nature as related to other animals, considering the succession and descent of species, and the comparison of structure and brain endowments with inferior creatures. Chapter III is devoted to "The Races of Mankind," and is descriptive of their characteristics. The text is here illustrated by profuse and finely executed illustrations, of which we gave samples in the July "Monthly." The constitution, temperaments, types, permanence, mixture, and variation of races are here discussed, and the races of mankind are classified on the basis of these traits. The summary of the subject is admirable.

Chapters IV and V are devoted to "Language," which is of course considered as a problem of evolution. From the utterances of animals and the natural language of signs and gestures, and from emotional and imitative sounds, he proceeds to the origin of articulate language. The growth of meanings in articulate speech, abstract words, grammatical construction, and analytic and synthetic language, are then traced, with other important steps and elements of lingual development. Chapter VI, on "Language and Race," gives an account of the derivations and relationships of the languages used by different races; and Chap-

ter VII, on "Writing," takes up the subject of picture-writing, and the formation of alphabets.

Chapters VIII, IX, X, and XI, deal with the origin and development of the "Arts of Life," as shown in the construction of weapons, tools, machines, dwellings, clothing, in the means of navigation, in cookery and domestic processes, glass- and metal-working, money, and the operations of commerce.

Chapter XII delineates the origin and history of the "Arts of Pleasure," poetry, music, dancing, drama, painting, sculpture, and games; and Chapter XIII is an excellent monograph on the origin and growth of "Science."

In Chapter XIV, under the title of "The Spirit World," the religions of the lower races are taken up, and a description is given of the origin and influence of primitive ideas of souls, a future life, demons, gods, and worship. Chapter XV treats of "History and Mythology"; and Chapter XVI, which is the last, and entitled "Society," discusses the social stages, the family, property, justice, social ranks, and the growth of government.

It will be seen, from this brief synoptical view of the contents of his volume, that Mr. Tylor covers broad ground, but it will be found that the treatment of his topics is remarkably full and satisfactory. We cordially recommend his book to all students who desire to make a systematic study of man a part of their education, and we may add that the ordinary reader will find it full of interest and instruction.

Illusions: A Psychological Study. By James Sully. New York: D. Appleton & Co. Pp. 372. *International Scientific Series No. XXXIV.* Price, $1.50.

The author of this work is now well known to the scholarly world by his original and comprehensive treatises on "Sensation and Intuition," and on "Pessimism." He is entirely familiar with modern philosophical problems, and has given critical attention to the bearings of science upon the class of questions that has interested him.

In the present volume he has taken up the subject of "Illusions" from a new point of view. Hitherto illusions have been commonly regarded as of the nature of mental aberrations or hallucinations, excluding the idea of sane intelligence. Illusions from this standpoint are allied to insanity, and their study is considered as belonging to the professional alienist or the physician occupied with mental derangements. There is, of course, abundant ground for this treatment of the subject, but Mr. Sully assumes that the subject has a far wider aspect, and can by no means be properly confined to the domain of pathology.

The author considers, on the other hand, that the liability to illusion is natural, and that it is but a part of that capacity for error which belongs essentially to rational human nature. All men err, some more habitually and more widely than others; but there are errors of illusion that belong to the normal operation of the human faculties, the study of which is quite as much related to the physiology as to the pathology of mind. It is therefore a legitimate problem of the psychologist who analyzes the conditions of sound and healthy mental action.

From this point of view the author remarks: "In the present volume an attempt will be made to work out the psychological side of the subject; that is to say, illusions will be viewed in their relation to the process of just and accurate perception. In the carrying out of this plan our principal attention will be given to the manifestations of the illusory impulse in normal life. At the same time, though no special acquaintance with the pathology of the subject will be laid claim to, frequent references will be be made to the illusions of the insane. Indeed, it will be found that the two groups of phenomena—the illusions of the normal and of the abnormal condition—are so similar, and pass into one another by such insensible gradations, that it is impossible to discuss the one apart from the other. The view of illusion which will be adopted in this work is that it constitutes a kind of border-land between perfectly sane and vigorous mental life and dementia."

Thus regarded, the study of illusions becomes properly a branch of logic; that is, it involves fundamentally the discrimination of that which is true from that which is false. The author at the outset makes a

definition and explanation which implies this idea. He says: "Taking this view of illusion, we may provisionally define it as any species of error which counterfeits the form of immediate, self-evident, or intuitive knowledge, whether as sense-perception or otherwise. Whenever a thing is believed on its own evidence and not as a conclusion from something else, and the thing then believed is demonstrably wrong, there is an illusion. The term would thus appear to cover all varieties of error which are not recognized as fallacies or false inferences. If for the present we roughly divide all our knowledge into the two regions of primary or intuitive, and secondary or inferential knowledge, we see that illusion is false or spurious knowledge of the first kind, fallacy false or spurious knowledge of the second kind. At the same time, it is to be remembered that this division is only a very rough one. As will appear in the course of our investigation, the same error may be called either a fallacy or an illusion, according as we are thinking of its original mode of production or of the form which it finally assumes; and a thorough-going psychological analysis of error may discover that these two classes are at bottom very similar."

It will be obvious that this is not a technical work, but one of wide popular interest, in the principles and results of which every one is concerned. The illusions of perception of the senses and of dreams are first considered, and then the author passes to the illusions of introspection, errors of insight, illusions of memory, and illusions of belief. The work is a noteworthy contribution to the original progress of thought, and may be relied upon as representing the present state of knowledge on the important subject to which it is devoted.

Literary Style and other Essays. By William Mathews, LL. D. Chicago: S. C. Griggs & Co. Pp. 345. Price, $1.50.

A most readable volume, full of common sense and practical wisdom on a great number of important and interesting subjects. The author is evidently an omnivorous and careful reader, and has well cultivated the art of turning his varied studies to good literary account. His pages are loaded, we might almost say overloaded, with references to the best writers, and quotations of their trenchant and suggestive sayings. The first paper, on "Literary Style," from which the volume takes its name, is not a scientific or philosophical analysis of the subject, but is a formidable array of arguments, illustrations, and authorities to prove that literary form is the main thing in the art of authorship. Dr. Mathews shows that, in literature, ideas, facts, and the substance of thought go for next to nothing, while the style of verbal dress determines the place and permanence of literary productions. The following passage on Carlyle will exemplify the fundamental idea of the essay, and illustrate also the author's lively and earnest style of discussion:

Perhaps no other writer of the day has more powerfully influenced the English-speaking race than Carlyle. Beyond all other living men he has, in certain important respects, shaped and colored the thought of his time. As an historian, he may be almost said to have revolutionized the French Revolution, so different is the picture which other writers have given us from that which blazes upon us under the lurid torch-light of his genius. To those who have read his great prose epic, it will be henceforth impossible to remember the scenes he has described through any other medium. As Helvellyn and Skiddaw are seen now only through the glamour of Wordsworth's genius—as Jura and Mont Blanc are transfigured, even to the tourist, by the magic of Byron and Coleridge—so to Carlyle's readers Danton and Robespierre, Mirabeau and Tinville, will be for ever what he has painted them. No other writer equals the great Scotchman in the Rembrandt-like lights and shadows of his style. While, as Mr. McCarthy says, he is endowed with a marvelous power of depicting stormy scenes and rugged, daring natures, yet, at times, strange, wild, piercing notes of the pathetic are heard through his fierce bursts of eloquence like the wail of a clarion thrilling beneath the blasts of a storm. His pages abound in pictures of human misery sadder than poet ever drew, more vivid and startling than artist ever painted. In his conflict with shams and quackeries he has dealt yeomen's blows, and made the bankrupt institutions of England ring with their own hollowness. What is the secret of his power? Is it the absolute *novelty* of his thoughts? In no great writer of equal power shall we find such an absolute dearth of new ideas. The gospel of noble manhood, which he so passionately preaches, is as old as Solomon. Its cardinal ideas have been echoed and reëchoed through the ages till they have become the stalest of truisms. That brains are the measure of worth; that duty, without reward, is the end of life;

that "work is worship"; that a quack is a Falsehood incarnate; that on a lie nothing can be built; that the victim of wrong suffers less than the wrong-doer; that man has a soul that cannot be satisfied with meats or drinks, fine palaces and millions of money, or stars and ribbons—this is the one single peal of bells upon which the seer of Chelsea has rung a succession of changes, with hardly a note of variation, for over half a century. Anything more musty or somniferous than these utterances, so far as their substance is concerned, can hardly be found outside of Blair's sermons. Coming from a common writer, they would induce a sleepiness which neither "poppy, mandragora, nor all the drowsy sirups of this world" could rival in producing. But preached in the strong, rugged words and with the tremendous emphasis of Carlyle; enforced by sensational contrasts and epic interrogations; made vivid by personification, apostrophe, hyperbole, and enlivened by pictorial illustration—these old saws, which are really the essence of all morality, instead of making us yawn, startle us like original and novel fancies.

The volume comprises upward of twenty essays, among which "The Duty of Praise," "A Plea for the Erring," "Hot-house Education," "The Art of Listening," and "Office-Seeking," are especially noteworthy.

The Bolometer and Radiant Energy. By Professor S. P. Langley. Reprinted from the "Proceedings of the American Academy of Arts and Sciences." Cambridge: University Press. Pp. 16.

The Bolometer. By Professor S. P. Langley, Allegheny Observatory, Pennsylvania. Read before the American Metrological Society, December, 1880. New York: Published by the Society. Pp. 7.

Recognizing that the prism does not give the true values for the heat of the spectrum, and that it displaces the maximum ordinate of the heat-curve, the author has constructed and used a new apparatus—the "Bolometer," or "Actinic Balance," for the purpose of gaining a more actual value of the heat, the description of which and its operation is the chief purpose of these papers. With this instrument he has reached the interesting and unexpected conclusion that "the great proportion of all solar heat received at the earth's surface does not apparently lie in the non-luminous parts of the spectrum. Not only is the heat-maximum in the luminous part, but the total sum of non-luminous heat (so far at least as our measures extend) is relatively small."

Second German Book after the Natural or Pestalozzian Method for Schools and Home Instruction. By James H. Worman, A. M., author of a Series for Modern Languages, etc., and Professor in the Adelphi Academy, Brooklyn, New York. New York and Chicago: A. S. Barnes & Co. Pp. 84. Price, 40 cents.

The plan of the course of which this volume is a part has been developed during the practice of teaching German. Its general features are exclusive use of the German language without the help of the learner's vernacular; attention to grammatical and lexical details; the deduction of the rules from the examples; teaching by contrast and association; and graded lessons made up of conversations on familiar topics, so arranged as to supply a stock of words for daily use in common affairs.

Report on Foreign Life-saving Apparatus. By Lieutenant D. A. Lyle, Ordnance Department, U. S. A. Washington: Government Printing-Office. Pp. 48, with Nineteen Plates.

Several lots of foreign life-saving rockets were sent to Sandy Hook, New Jersey, in the spring of 1879, for examination and trial, under the inspection of the author. They were stored for several months under ordinary conditions of exposure, and then inspected and experimented with. The report describes the experiments and the results obtained with the Russian, German, English, and Hooper apparatus.

Geological Survey of Alabama: Report of Progress for 1879 and 1880. By Eugene A. Smith, Ph. D., State Geologist. Montgomery, Alabama: Allred & Beers, State Printers. Pp. 158, with Maps.

The principal feature of the operations was the survey of the Black Warrior River and Warrior Coal Field, from Tuscaloosa to Sipsey Fork, conducted with a view partly to estimate the resources of the country, partly to ascertain the nature and extent of the obstructions to navigation, and the cost of removing or overcoming them. A report, by Henry McCalley, on the counties lying north of the Tennessee River is also included. Particular reports, with analysis, are given of fifty mines or outcrops of coal in the Warrior Field.

American Nervousness, its Causes and Consequences. A Supplement to Nervous Exhaustion (Neurasthenia). By George M. Beard, A. M., M. D. New York: G. P. Putnam's Sons. Pp. 352. Price, $1.50.

The author believes that nervousness—"strictly, deficiency or lack of nerve-force"—is a modern affection, and that it is manifested in the United States through a variety of symptoms that are peculiar in many respects to the country, and remarkable. He ascribes its great development and rapid increase chiefly and primarily to modern civilization, which is different from the ancient civilization by a number of characteristics which breed mental activity and anxiety about time-tables, and excitements about matters of politics and business, for which the ancients had only a limited concern. It is aided by secondary and tertiary causes which might be comparatively unimportant in themselves alone, but which, combined with each other and with the chief cause, exert each its own kind and degree of effect. The symptoms by which this nervousness is manifested, numerous as they are, and unpleasantly as they often exhibit themselves, do not all betoken ill to the country; for brain-workers have in all ages been long-lived, longevity increases apace with nervousness; good taste, the beauty of women, the faculty of humor, the eloquence of oratory, increase with it; the evil of it tends, within certain limits, to correct itself; "and the physical future of the American people," says the author, "has a bright as well as a dark side; increasing wealth will bring increasing calm and repose; the friction of nervousness shall be diminished by various inventions; social customs shall be modified, and as a consequence strength and vigor shall be developed at the same time with, and by the side of, debility and nervousness."

The Library. By Andrew Lang. With a Chapter on Modern English Illustrated Books, by Austin Dobson. London: Macmillan & Co. Pp. 184. Price, $1.25.

The purpose of this work is explained in its own pages thus: "There are, in every period of taste, books which, apart from their literary value, all collectors admit to possess, if not for themselves, then for others of the brotherhood, a peculiar preciousness. These books are esteemed for curiosity, for beauty of type, paper, binding, and illustrations, for some connection they may have with famous people of the past, or for their rarity. It is about these books, the method of preserving them, their enemies, the places in which to hunt for them, that the following pages are to treat."

The Microscope and its Relation to Medicine and Pharmacy. Edited and published by Charles H. Stowell, M. D., Assistant Professor of Physiology and Histology, University of Michigan, and Louisa Reed Stowell, M. S., Assistant in Microscopical Botany, University of Michigan. An Illustrated Bimonthly Journal, Vol. I, No. 1. Ann Arbor, Michigan. Detroit: George S. Davis. Pp. 32. Price, $1 per year.

While, in other medical journals that give attention to microscopy, microscopic topics are made secondary to medical ones, the conductors of this journal intend to give the most prominence to those subjects especially related to the microscope. The present number contains four original articles in the special department of the magazine, and presents matters of general interest to physicians and pharmacists, under the heading of "Editorial Abstracts."

Principal Characters of American Jurassic Dinosaurs. By Professor O. C. Marsh. Pp. 7, with Seven Plates.

The discovery of a nearly complete skeleton of *Brontosaurus* has added many new points to our knowledge of the group of *Dinosauria*, some of which are given in the present paper. A second species, equally gigantic in size, has since been found, and two new genera from the same formation, all of which are noticed, and an outline of classification of the group is proposed.

Information for Emigrants. The Climate, Soils, Timbers, etc., of Kentucky, contrasted with those of the Northwest. By John R. Procter. Frankfort, Kentucky: Kentucky Geological Survey and Bureau of Immigration. Pp. 29.

The Bureau of Immigration has already issued several publications setting forth the resources of Kentucky. Persons interested in the settlement of the Northwest have pub-

lished statements of the great advantages which that section offers to immigrants. The present tract is designed to exhibit the disadvantages of the Northwest, so as to prevent attention being turned away too much from Kentucky. The labor was not necessary. The advantages of Kentucky are too real and too well known to need exaltation through the depreciation of those of other parts of the Union.

Inductive Metrology. By W. J. McGee. Pp. 8.

Following up the suggestions of Mr. Petrie's English work on the "Recovery of Ancient Measures from the Monuments," the author insists on the necessity of more numerous and accurate measurements of the works of our American prehistoric races. The prevalent belief that the mound-builders used no unit of linear measure is contradicted by the measurements given by Messrs. Squier and Davis, by Mr. Petrie's deductions from them, and by the author's investigations. Computations made on these three bases nearly agree in giving a unit corresponding to 2·140 feet or 25·68 inches, with a possible error of ·0384.

Nostrums in their Relations to the Public Health. By Albert B. Prescott, M. D., F. C. S., Professor of Applied Chemistry in the University of Michigan. Pp. 12.

Professor Prescott relates the results of the analyses made by himself and others of a considerable number of nostrums, which show that none of them contain anything new or rare, though many of them pretend to; that while many of them contain only what is at the best worthless, some contain substances that are actively injurious; that the composition of some is uncertain because it is often changed at the fancy of the proprietor; and that as a rule nostrums are better not used.

On Philadelphite (Sp. Nov.). By Henry Carvill Lewis. Pp. 16.

This paper is a description of a new mineral belonging to the vermicular group of hydrous silicates, occurring disseminated and in scales, and in seams in the hornblendic gneiss of parts of Philadelphia, which exhibits some remarkable properties.

On the Geographical Distribution of the Indigenous Plants of Europe and the Northeast United States. By Joseph F. James. Cincinnati, Ohio. Pp. 17.

The author believes that the species of plants common to Europe and America have had a common origin in the land about the north pole, and that they have migrated southward as the cold has increased in the Arctic regions; that on account of the present arrangement of isothermals some species reach in Europe a latitude higher by twenty degrees than that in which they are found in America; that the chain of the Rocky Mountains and the Andes furnishes or has furnished a highway for the dispersion of some Arctic forms over the southern hemisphere; and that the greater similarity between the floras of Europe, Northeast Asia, and Eastern America than between those of Asia and the American Pacific coast may be accounted for by reference to peculiarities of climatic conditions.

Annual Report of the Operations of the United States Life-saving Service for the Fiscal Year ending June 30, 1880. Washington: Government Printing-Office. Pp. 391. With Plates.

The record of the year covered by this report surpasses any previously made by the establishment. The service was distributed among 179 stations, of which 139 were on the Atlantic, 34 on the Lakes, and 6 on the Pacific. Three hundred disasters occurred within the scope of its operations, imperiling property to the value of $3,811,708, and the lives of 1,989 persons. Nineteen hundred and eighty of the men were saved, only nine being lost, and $2,619,807 worth of property were secured. The report gives the details of the operations and of the disasters.

The School of Life. By William Rounseville Alger. Boston: Roberts Brothers. Pp. 205. Price, $1.

An essay, the scope of which is fairly described by the general subject of the title. It relates principally to the discipline and culture which we receive from our presence in the world and its action upon us, the use we should make of the opportunities it affords, and the methods by which we may attain the best-rounded manhood.

Rapid Breathing as a Pain-Obtunder in Minor Surgery, Obstetrics, and the General Practice of Medicine and of Dentistry. By W. G. A. Bonwill, D. D. S. Pp. 16.

The author describes some experiments by which he has been led to assert that he can produce, from rapidly breathing common air, a similar effect to that from ether, chloroform, and nitrous oxide gas, in their primary stages, and can thus render patients sufficiently insensible to acute pain from any operation where the time consumed is not over twenty or thirty seconds. While the special senses are in partial action, the sense of pain is obtunded, and in many cases completely annulled, consciousness and general sensibility being preserved. He has used his method satisfactorily in his dental practice for four years, and refers to Dr. Hewson as having used it in obstetrics for three years.

Gill-Nets in the Codfishery: A Description of the Norwegian Cod-Nets, with Directions for their Use, and a History of their Introduction into the United States. By Captain J. W. Collins. Bulletin, U. S. Fish Commission, I. 1881. Pp. 17, with Nine Plates.

The Fish Commission, believing the gill-nets to be a valuable fishing apparatus, has exerted itself to have them introduced and generally used in the United States. The present pamphlet is a part of its effort. The title furnishes a sufficient index to its reading contents. The plates exhibit the construction and method of setting and using the nets, to the minutest detail.

Annual Report of the Chief-Engineer of the Water Department of the City of Philadelphia for the Year 1880. Presented to Councils, May 5, 1881. Philadelphia: John D. Avil & Co. Pp. 128.

A noteworthy feature of this report is that it seems to show that the water-power of the Schuylkill has been highly overrated, and has not half the value at which it has been estimated; hence attention should be diverted from water-power and turned to steam-power as a means of propelling the machinery by which a steady supply of water is to be secured from such works as those on which Philadelphia depends.

Antiquities of New Mexico and Arizona. By W. J. Hoffman, M. D., U. S. A. Davenport, Iowa: Academy of Natural Sciences. Pp. 20, with Five Plates.

This monogram gives a tolerably full and very satisfactory description of the situation, construction, and present condition of the so-called ancient Pueblos, with notices of the potteries and other relics found in them, and some measurements of skulls. The figures in the plates are representations of numbered specimens in the National Museum.

Political Eloquence in Greece: Demosthenes. With Extracts from his Orations, and a Critical Discussion of the "Trial of the Crown." By L. Brédif. Translated by M. J. MacMahon, A. M. Chicago: S. C. Griggs & Co. Pp. 510. Price, $3.

A series of essays on the life, surroundings, character, gifts, and public services of Demosthenes, and the general subject of "political eloquence in Greece." An analysis is given of the principal elements and characteristics of Demosthenes's eloquence.

PUBLICATIONS RECEIVED.

Ether-Death. By John B. Roberts, M. D. Philadelphia. 1881. 12 pages.

Catalogue of Exhibits at the Third Annual Reception of the Rochester Academy of Science. Rochester. 1881. Pp. 34.

The Saratoga Mineral Waters. Directions for their Use. By Dr. W. O. Stillman. New York: Taintor Brothers, Merrill & Co. 1881. Pp. 57. Illustrated.

Papers read before the Pi Eta Scientific Society, Rensselaer Polytechnic Institute, Troy, New York. 1881. Vol. II, No. 2. Pp. 101.

Studies from the Biological Laboratory of Johns Hopkins University. Edited by H. Newell Martin and W. K. Brooks. Vol. II, No. 1. 1881. Pp. 134. Illustrated.

On the Pathology and Treatment of Chorea, pp. 4; and Some Considerations on Insanity and its Therapeutics, pp. 7. By Edward C. Mann, M. D. New York. 1881.

The State and Higher Education. An Address before the Minnesota Academy of Natural Sciences. By Professor N. H. Winchell. Minneapolis. 1881. Pp. 18.

Objects of Sex and of Odor in Flowers. By Thomas Meehan. Philadelphia: "Gardener's Monthly" print. 1881. Pp. 3.

Anticipation of Lissajou's Curves. By Joseph Lovering. Pp. 7. With Plate. Large Telescopes. By Edward C. Pickering. Pp. 6. From "Proceedings of the American Academy of Arts and Sciences." 1881.

The New York Water-Supply. Report of Isaac Newton, Chief-Engineer, and Opinion of E. S. Chesbrough, Consulting Engineer. New York. 1881. Pp. 14.

The Solar Parallax as derived from the American Photographs of the Transit of Venus, December 8–9, 1874. By D. P. Todd, M. A. From "American Journal of Science," June, 1881. Pp. 3.

Brief Review of the Most Important Changes in the Industrial Applications of Chemistry within the Last Few Years. By J. W. Mallet, F. R. S. From "American Chemical Journal." Pp. 98.

Color-Blindness. Remarks by Dr. B. Joy Jeffries at the Twenty-ninth Annual Meeting of the Board of Supervising Inspectors of Steam-Vessels, January 25. 1881. Pp. 31.

Report of the Analytical and other Work done on Sorghum and Cornstalks by the Chemical Division of the Department of Agriculture, Peter Collier, Chemist. Washington: Government Printing-Office. 1881. Pp. 101. Twenty-seven Plates.

American College Directory and Universal Catalogue. Vol. III. 1881. St. Louis, Missouri: C. H. Evans & Co. Pp. 105.

Seedless Fruits. By E. Lewis Sturtevant, M. D. South Framingham, Massachusetts. Pp. 29.

Photometric Measurements of the Variable Stars β Persei and D. M. 81°·25. By Edward C. Pickering, Arthur Searle, and O. C. Wendell. From "Proceedings of the American Academy of Arts and Sciences." Cambridge. 1881. Pp. 27.

On the Action of Hyponitric Anhydride on Organic Bodies, pp. 13; and On the Production of Ozone by Heating Substances containing Oxygen. Pp. 5. By Albert R. Leeds. From "Journal of the American Chemical Society."

Fatal Form of Septicæmia in the Rabbit produced by the Subcutaneous Injection of Human Saliva. An Experimental Research. By Dr. George M. Sternberg, Surgeon United States Army. Baltimore. 1881. Pp. 22. Illustrated.

Transactions of the Seismological Society of Japan. Vol. I. Parts I and II, April–June. 1880. Printed at the Office of the "Japan Gazette." Pp. 116.

Discovery of Palæolithic Flint Instruments in Upper Egypt. By Professor Henry W. Haynes. From "Memoirs of American Academy of Arts and Sciences." 1881 Pp. 5. Seven Plates.

"The Magazine of Art," June, 1881. Cassell, Petter, Galpin & Co. London and New York.

Papers of the Archæological Institute of America. By A. F. Bandelier. Boston: A. Williams & Co. 1881. Pp. 133.

Ranthorpe. By G. H. Lewes. New York: William S. Gottsberger. 1881. Pp. 326. 75 cents.

The Emperor. A Romance. By Georg Ebers. From the German. By Clara Bell. 2 vols. New York: William S. Gottsberger. 1881. Per volume, 40 cents.

Rugby, Tennessee. By Thomas Hughes. London: Macmillan & Co. 1881. Pp. 168. $1.

A Theory of Gravitation, Heat, and Electricity. By Melville Marborg. Baltimore: John B. Piet. 1881. Pp. 104.

Sewer-Gas and its Dangers. By George Preston Brown. Chicago: Jansen, McClurg & Co. 1881. Pp. 242. $1.25.

Synopsis of the Fresh-Water Rhizopods. By Romyn Hitchcock. New York: published by the author. 1881. Pp. 56.

The Disposal of the Dead; a Plea for Cremation. By Edward J. Bermingham. M. D. New York: Bermingham & Co. 1881. Pp. 89. $2.

Osteology of Speotyto and Eremophila. By R. W. Shufeldt. Surgeon United States Army. Washington. 1881. Pp. 147. Illustrated.

Comparative New Testament. Old and New Versions arranged in Parallel Columns. Philadelphia: Porter & Coates. 1881. Pp. 690. $1.50.

A Text-Book on Anatomy, Physiology, and Hygiene. By J. T. Scovell. Terre Haute, Indiana, 1881. Pp. 88.

Butterflies; their Structure, Changes, and Life Histories. With Special Reference to American Forms. By Samuel H. Scudder. New York: Henry Holt & Co. 1881. $3.

POPULAR MISCELLANY.

Salmon of the Pacific Coast.—Messrs. David S. Jordan and Charles H. Gilbert, who have been engaged in the study of the fishes of the Pacific coast, state in the abstract of their report, which is published in the "American Naturalist," that they have observed five species of salmon (*Oncorhyncus*) in the waters of the North Pacific. These species may be called the quinnat or king-salmon, the blue-black salmon or red-fish, the silver salmon, the dog-salmon, and the hump-back salmon; and they are known by many other and vernacular names. The quinnat and blue-black salmon habitually *run* in the spring, the others in the fall, the two former species having the greater economic value. The spring-running salmon ascend only those rivers which are fed by the melting snows from the mountains. and which have sufficient volume to send their waters well out to sea, as the Sacramento, Rogue, Klamath, Columbia, and Frazer Rivers. They are chiefly adults, but their milt and spawn are no more developed in them when they go up the rivers than they are at the same time in others of the same species which will not enter the streams until fall. High water in any of these rivers in the spring is always followed by an increased run of fish, and it is believed that the disposition to run is excited by contact with cold water. The average weight of the quinnat in the spring is twenty-two pounds in the Columbia River, and about sixteen pounds in the Sacramento River. Individuals weighing from forty to sixty pounds are frequently found in both rivers, and some as heavy as eighty pounds. Fish that enter the rivers in the spring continue to ascend until death or spawning overtakes them. Probably none of them ever return to the ocean, and a large proportion fail to spawn. They are known to ascend the Sacramento to its extreme head-waters, about four hundred miles, and the Columbia as far as the Spokan Falls, a dis-

tance of between six and eight hundred miles. At these distances the bodies of the fish become covered with bruises, in which patches of white fungus are developed; their fins become mutilated, their eyes are often destroyed, parasitic worms gather in their gills, they become emaciated, the flesh becomes white from the loss of the oil, and they all die as soon as the spawning act is accomplished, often before. So far as has been observed, they are not known to feed after entering the rivers. The spawning-season varies in different rivers, and different parts of the same river, but not in the different species, and probably extends from July to December. In the spring the fish are silvery, spotted or not, according to the species, and have the mouth about equally symmetrical in both sexes. As the spawning-season approaches, the female loses her silvery color, and becomes more slimy, the scales on the back partly sink into the skin, and the flesh changes from a salmon-red to a paler color. As the season advances, the differences between the males and females become more marked, in proportion as the milt is developed. The difference in the economic value of the spring and fall salmon, which is vastly in favor of the former, is dependent on the fact that the spring salmon enter the rivers long before the growth of the organs of reproduction has reduced the richness of the flesh, while the fall salmon can not be taken in quantity until their flesh has deteriorated. The quinnat is more valuable, on account of its size and abundance, than all the other fishes on the Pacific coast together; and the blue-back is worth much more than the combined value of the three remaining species. "It is the prevailing impression," say the authors of the report, "that the salmon have some special instinct which leads them to return to spawn in the same spawning-grounds where they were originally hatched. We fail to find any evidence of this in the case of the Pacific coast salmon, and we do not believe it to be true. It seems more probable that the young salmon, hatched in any river, mostly remain in the ocean within a radius of twenty, thirty, or forty miles of its mouth. These, in their movements about in the ocean, may come into contact with the cold waters of their parent rivers, or perhaps of any other river, at a considerable distance from the shore. In the case of the quinnat and the blue-back, their "instinct" leads them to ascend these fresh waters, and, in a majority of cases, these waters will be those in which the fish in question were originally spawned. Later in the season the growth of the reproductive organs leads them to approach the shore and to search for fresh waters, and still the chances are that they may find the original stream. But undoubtedly many fall salmon ascend or try to ascend streams in which no salmon was ever hatched." The evidence is not clear whether salmon are diminishing in numbers or not, except in the Sacramento River, where they are undoubtedly decreasing.

Storage of Electricity.—The reproach against electricity that it can not be stored seems now to be in a fair way of being removed by M. Camille Faure's recent improvement of the Planté secondary battery. The cells of this battery, as is well known, consist simply of two lead plates immersed in acidulated water, one of which becomes oxidized by the passage of a current through the cell, and is reconverted into the metallic state when the charging current ceases, yielding a current while undergoing this latter transformation. Once charged, the battery may be kept a considerable length of time without losing its power, and gives out a current steadily in a manner similar to an ordinary voltaic cell. The Planté cell is, however, not of commercial value, as its capacity is small, and it requires a considerable time to charge it. These difficulties M. Faure appears to have largely overcome by simply coating the plates with minium or red-lead, whereby their chemical dissimilarity, and consequently the electrical capacity of the cell, is greatly increased. When the charging takes place, the minium upon one plate is further oxidized to the peroxide, and that upon the other reduced to the metallic state, a current being given out while these plates are assuming their original condition. The cell is stated to give eighty per cent. of the current used to charge it, and to retain its charge for a considerable period. A battery containing four cells, and of the size of a cubic foot, was recent-

ly sent from Paris to Sir William Thomson at Glasgow, which was found by him to contain electrical energy equal to something over one million foot-pounds, or one-horse power, for one hour. Though the battery was seventy-two hours reaching him, it was found to have lost but very little of its original charge, and he has since been able to detect but a slight loss in a period of ten days. The expectations regarding the uses to which this battery can be put are doubtless exaggerated, but it seems safe to predict for it a large field of usefulness. It can probably be employed to advantage, if further experiment bears out present statements regarding it, wherever ordinary batteries are used, as it possesses the convenience of these combined with the cheapness of the dynamo-machine in the matter of the currents furnished. In the electric-light it will probably find an important use in equalizing the currents of the machines, and preventing interruption of the light in case of a temporary failure of the generating apparatus. It is, moreover, not impossible that it may dispense with the need for electrical distribution at all, as such batteries placed in houses could be charged each day by small dynamo-machines driven by gas-engines, at but small expense and with the minimum amount of trouble.

Color-Blindness and Education of the Color-Sense.—The examinations instituted by Dr. B. Joy Jeffries among the pupils in the schools of Boston (including 14,469 boys and young men and 13,458 girls and young women) have shown that about one male person in twenty-five is color-blind, while the defect occurs with extreme rarity in girls and women (only 0·066 per cent. of the female pupils in the schools). The researches that have been made in Europe show that a similar law as to the relative proportion of color-blindness between the sexes prevails there. The subject has been overlooked until within a few years, but the value of the knowledge of it that has been gained can not be disputed. This knowledge can be applied practically on a scale of considerable extent in determining the vocation to which boys should be trained. A person who is color-blind is obviously unfit for any business in which he must know how to distinguish colors. Yet the person himself and those who are around him are seldom aware of his defect. If examinations are regularly made in the schools and records kept of them, as has been done by Professor Jeffries, a sure practical test may be found which can be applied directly to each person, so as to guide him aright on this point. The inquiries of Dr. Jeffries have disclosed a great lack of knowledge of colors, aside from color-blindness, among adults as well as among the boys in the schools. But very few boys of the grammar or higher schools, he says, are familiar with the color-names of even the primary colors, and still less can they correctly apply those names they do remember, when shown colored objects. "I have received letters from adults, not color-blind, whose lack of color-names had been a serious drawback to them in their occupations in every-day life; and they have besought me to urge the teaching of color-names and the education of the color-sense in our public schools." The teaching of colors and color-names has been partly introduced into our primary schools, but without any system; it has been begun in Europe, especially in Germany, in the lowest schools, in a systematic manner. The exemption of women from color-blindness has been attributed to their familiarity with colored objects and materials; but this holds only of the sex as a whole, not with reference to individuals, for the color-sense can not be changed with practice in colors. The question arises whether generations of color-education have caused this sexual difference, and is important; for, if answered in the affirmative, it proves that we may begin to eliminate color-blindness from future generations of boys by teaching and exercising the present generation in the perception and distinction of colors.

Climate and Health.—Mr. Alexander William Mitchinson has read an important paper in the Society of Arts on "The Principal Causes of Disease in Tropical Countries." It is usual to trace these causes back to the climate, but Mr. Mitchinson maintains that climate has less to do directly in producing disease than has generally been supposed. Every climate and country has its own appropriate and dietary laws, and

exacts obedience to them at the cost of sickness; but, when these laws are obeyed, the difference in the healthiness of climates becomes comparatively insignificant. Europeans going to tropical countries are apt to neglect the precautions with reference to food which the changed conditions of their life would require them to take, and, instead of reducing the quality and varying the nature of what they eat, too often grant themselves the indulgences of rich viands, with high seasonings and wines, which they enjoyed at home. The mistake is even made of increasing the quantity and richness of the food, under the impression that the exhaustion produced by the climate should be met in that way, while a lighter diet is what is really required. The stomach can not bear the burden imposed upon it, and symptoms of disease arise. The loss of memory and mental capacity, which have been remarked as effects of a long residence in the tropics, are partly due to tropical heat, but far more to the solitude, with insufficient variety of incident, and the want of mental exercise, to which residents are exposed by the lack of society and of the distractions which society promotes. "Europeans in Africa do little else than eat and drink, rest and sleep," will seek for nothing to occupy their minds, and will often sit listlessly for hours gazing at vacancy. Consequently the mind is apt, from want of judicious exercise, to sink gradually, and the man to fall into apathy. In such a condition he is far more liable to an attack of fever than one who has preserved his mind in a state of healthy vigor. Other mistakes committed by European residents, which almost surely lead to disease, are the excessive use of spirits—dangerous in the tropics above all other regions—carelessness in regard to exposure, and neglect of exercise. More or less of exposure to the atmospheric changes of the country is inevitable, and the body that is prepared to withstand them is in less danger from them than are the too sensitive organizations of those who take too much care of themselves. This preparation can be gained by judicious exercise at different periods of the day and year. The bad location, and neglect of the sanitary condition of the coast towns, are responsible for much of the unhealthiness which is associated with Africa. Many of them are built near marshes or lagoons, in the very worst places that could be selected, such as would be pestilential spots anywhere, and they have been suffered to grow up and accumulate nuisances without a thought of the application of sanitary science, which seems to be wholly unknown, to their improvement. The natives have an effectual means of warding off malaria by planting groves of trees between the swamps and their villages, or by burning the bush and allowing the soil exposed thereby to acquire a crust, which impedes the rising of the malarious vapors. "In the British possessions such obvious means of protection appear to be either unknown or despised." The rule of life Mr. Mitchinson would lay down for a resident in the tropics is based upon the words "diet, exercise, and energy." These, he says, are the man's climate, his life, the power of the intellect nourished by the normal blood. "The rule of life adopted by most Europeans in the tropics, so far as they can be said to have any rule, appears to be 'feed and rest, rest and feed"; few give any intelligent consideration to the subject of the preservation of health." It is no wonder, then, that European residents die early.

Movements and Mixtures of African Races.—Messrs. de Quatrefages and Hamy have presented an important paper on the craniology of the dolichocephalous negro races. These races occupy the most considerable part of the geographical area inhabited by the negro race on the African Continent. Regarded as a whole, they present a considerable homogeneity in the most essential characteristics; but differences of habitat and the mixture of foreign elements have caused their secondary characters, both exterior and anatomical, to vary within considerable limits. Consequently, they are divided into a considerable number of groups—groups which are increasing. The Soodanian group, which presents the most complete exemplification of the general type, occupies all the space comprised between the Sahara on the north, Senegambia on the west, Guinea on the south, and the valley of the upper Nile on the east. The Soodanians may be classified as eastern and western. The cranial capacity of the west-

ern Soodanians is probably inferior to that of all the other negro races of the same type, and exhibits a most pronounced dolicocephaly. The eastern Soodanians approach this type, but some of its most characteristic marks are less distinct in them. To them may be attached the negroes living on the banks of the upper Nile and the great lakes. Furthermore, a great variety is apparent among the races, and the ethnic mixtures are considerable. Africa is not, in fact, that stationary land which it is generally figured to be. It has, like the other continents, its grand movements of people and races. A current which is sometimes slow, sometimes more or less rapid, which seems to have existed for several centuries, is drawing the negro populations from the interior. Northeast of the Gulf of Guinea, toward the coast, the nature and importance of this movement, which is pushing the population from east to west, can be appreciated best at the Gaboon. There the Gaboonese first subjugated and absorbed the Negrilles, Akoas, and others; then the Bakales pushed them farther west; and the last are now pressed by the Fans, who are coming down from the interior. The Caffres are not a simple ethnic element, but are a mixture of negro and Bushman elements complicated with Arabian and even Malaysian elements. The Bushmen are the real indigenous race of Southern Africa; the Hottentots, the Koranas, the Gonaquas, and the Namaquas, are only hybrids of this race mixed in different degrees with the negro race.

Mr. Whymper's Experiments with "Mountain-Sickness."—Mr. Edward Whymper, in relating the story of his ascent of the mountains Chimborazo and Cotopaxi, has described the efforts which he made to counteract the "mountain-sickness" or sense of exhaustion and feverishness which attacks all persons who venture to great heights. Till his own attempt was made, he had not known of any traveler afflicted with the peculiar feeling who had deliberately "sat it out, and had a pitched battle with the enemy," or of any one who had suggested the bare possibility of coming out victorious from such an encounter, yet, upon doing so, he felt, depended the chance of pushing explorations into the highest regions of the earth, and he was anxious to test whether his organization could not accommodate itself to the required conditions. Only three well-authenticated instances were known of persons who had reached the height of twenty thousand feet, and their stories gave no light on the subject; but a person who had reached the height of between seventeen and eighteen thousand feet told him that, though he never had suffered from the affection, he could not escape it at such elevations. On the first day of his ascent of Chimborazo, he reached a height of 14,400 feet. On the next day he reached 16,500 feet, and established himself there with great difficulty. "The mules were forced up to the very last yard that they could go, and, staggering under their burdens, which were scarcely more than half the weight they were accustomed to carry, stopped repeatedly, and by their tremblings and falling on their knees, and general behavior, showed that they had been driven to the very verge of exhaustion." Within an hour Mr. Whymper and his Italian mountaineers, the Carrels, were lying on their backs, incapable of making the least exertion, feverish, with intense headaches, and unable to satisfy their desire for air, except by breathing with open mouths. "This naturally parched the throat, and produced a craving for drink which we were unable to satisfy, partly from the difficulty of obtaining it, and partly from the difficulty of swallowing it, for, when we got enough, we were unable to drink, we could only sip; and not to save our lives could we have taken a quarter of a pint at a draught. Before one tenth of it was down, we were obliged to stop for breath, and gasp again, until our throats were as dry as ever. Besides having our normal rate of breathing largely accelerated, we found it impossible to get along without every now and then giving a spasmodic gulp, just like fishes when taken out of the water. Of course, there was no desire to eat; but we wished to smoke; and even our pipes almost refused to burn, for they, like ourselves, wanted more oxygen." He obtained relief by taking chlorate of potash, and in two or three days the party had become accustomed to the situation, and were able to continue their work. The next camp was pitched at a height of 17,400 feet.

The more disagreeable symptoms had gone, but the mountaineers still found themselves "comparatively lifeless and feeble, with a strong disposition to sit down when we ought to have been moving." At length, having spent three days in moving their camp, and having passed a night at the highest station, they undertook the ascent to the summit. It was extremely difficult, made in the face of a high wind and through soft snow in which the men sunk to their necks, but it was accomplished, the measurement of the height was taken, and the return safely made to the camp, all in one day. The most notable physical experience of the ascent was the observation, at a height of between 18,400 and 19,500 feet, that "our steps got shorter and shorter, until at last the toe of one foot touched the heel of the previous one." Mr. Whymper's residence on Chimborazo "extended over seventeen days; one night was passed at a height of 13,400 feet, ten nights at a height of 16,500 feet, six at 17,300 feet. During this time, besides the ascent to the summit, I also went three times as high as 18,300 feet. When we quitted the mountain, all traces of mountain-sickness had disappeared, nor did it touch us again until we arrived at the summit of Cotopaxi." The camp on the latter mountain was placed about 130 feet below the loftiest point, or at a height of 19,470 feet, "and was the most elevated position at which any of us had ever lived. We remained there twenty-six consecutive hours, feeling slightly at first the effects of the low pressure, having the same symptoms as we noticed on Chimborazo; and we used chlorate of potash, and remarked its good effects. All the signs of mountain-sickness had passed away before we commenced the descent, and they did not recur again during the journey." The member of the party who suffered least from mountain-sickness was Mr. Perrin, the interpreter, who was in bad health from having led a dissipated life, and "could not walk a quarter of a mile on a flat road without desiring to sit down"; but he had lived for a long time at heights of between 9,000 and 10,000 feet, and had several times passed over a height of more than 14,000 feet; so that he was partly inured to the rarefied air. Chimborazo was visited again six months after the first visit, and a second measurement of the height was made. The mean of the two measurements gives 20,517 feet.

Structure of the Organs of Touch.—M. Ranvier has been much assisted in his investigation of the structure of the organs of touch by the examinations of the structure of infants. At birth, the nerves of touch may be found to pass into certain papillæ, on the palmar aspect of the fingers, immediately beneath the cells of the mucous layer of Malpighi, where they form a network of ramifications which, though distinct, are closely pressed together. No cellular elements are at this time mixed with the network, but a small collection of round cells exists beneath it. These gradually surround the network and pass in among its branches; the whole soon becomes united, and a tactile corpuscle is formed. Sometimes the corpuscle remains unilobar, but more frequently other lobes are formed in the same manner as the first one, and are joined to it. Hence it is that, in young children, the nerve-fibers which enter into the composition of the tactile corpuscles are separated by layers of cells, which, in the course of development, become pushed to the periphery of each lobe, and the most of them undergo a considerable atrophy. This fact suggests that they are not nervous in their nature, for the nerve-cells, so far from undergoing atrophy during growth, gradually increase in size to their full development. M. Ranvier has not perceived any communication between the nerve-fibers and the cells in the tactile corpuscle; the ramifying branches of the nerve-fibers, after a tortuous and usually complicated course, end in free, flattened knobs.

Influence of Physical Structure on Processes of Dyeing.—M. Gustave Engel has been engaged for several years in studying the influence which the physical structure of substances exercises upon the operations of dyeing, and has remarked that certain sands, composed of silica, a substance chemically inert, behave, in the presence of different coloring-matters and dyes, exactly in the same manner as cotton and wool. On examining with a microscope siliceous sands

having this property, they are found to be composed of the carapaces of tubular diatoms, formed of rings placed one upon the other. Each grain of the sand is, in fact, a minute tube of exceedingly fine silica, forming a mineral fiber which, by virtue of capillarity, retains coloring-matters with the same force as do vegetable or animal fibers dyed under the same conditions, and that without any chemical combination having taken place. M. Engel has exhibited to the Industrial Society of Mulhouse specimens of silica colored with alizarine rose, with indigo blue, and with a deep green produced by dyeing in logwood silica colored with iron, in all of which cases the siliceous sand had been treated as if it were cotton. Other specimens showed that the same sand behaved like wool in the presence of certain coloring-matters, especially of those derived from aniline. The experiments then make known a mineral substance which has properties of physical structure analogous to those of animal and vegetable fibers that are susceptible of being dyed, the likeness being given by the minute central canal, which enables each of the microscopic tubes to absorb the coloring-matter through capillary attraction, and to fix it so that it will resist chemical agents in the same manner as do organic fibers similarly colored. "These examples," says M. Engel, "tend to prove the new fact which I have been trying to establish, that the physical structure of substances submitted to the process of dyeing is of much more importance than their chemical composition, even if it is not the only factor in the process, as my experiments make it seem probable that it is."

M. Soleillet on the Sahara.—M. Soleillet lately made a communication to a society of civil engineers on his recent journey in the Sahara. This journey, the fourth which he has made since 1872, was undertaken chiefly for the purpose of finding what products of the soil could be made to contribute to the traffic of the proposed trans-Saharan railroad. He discovered coal in the Djebel Aroun, saltpeter in the region of Ain-Sala; in his journey to the Soodan, he found the butter-tree, which has been known since the days of Park, and sent specimens of the vegetable butter to M. Thénard. This product furnishes a stearine which melts at a high temperature, and can be made to give a clear white light, and has already been employed by the English in tempering certain steels, and in oiling steam-engines. In his last journey, he discovered a plant, the *Fernan*, a kind of *Fucus*, the white juice of which takes the place of pitch with the Moors; incorporated into the wood with a hot iron, it makes an excellent calking for boats. Hoping to find in it a substitute for India-rubber, he gave some of the juice to M. Thénard, who extracted from it a substance having properties similar to those of India-rubber, except that it was not elastic. It could be perfectly vulcanized, and in that state was much like gutta-percha. An oil was extracted from it, and a resin which could be converted by heat into a beautiful and brilliant lacquer. M. Soleillet was prevented by robbers from reaching Timbuctoo, but beyond Ain-Sala he discovered a large extent of country marked by dunes running north and south, which were crossed by others running from east to west. Between these dunes were ponds of both fresh and salt water, which left, when they were dried up, rich, natural meadows. The country, having an area equal to about a quarter of that of France, possesses a healthy climate, and is inhabited by ten thousand people. Farther on is the mountainous district of Adrar, inhabited by an agricultural and commercial Berber population, with whom the Portuguese carried on an important commerce in the fifteenth century.

The Human Fossil of Schipka Cave.—A human jawbone, found in the Schipka Cave of Moravia, along with bones of the mammoth and a number of rude stone implements, exhibits, according to a description given by Professor Schaffhausen, of Bonn, some remarkable and suggestive peculiarities. It is a fragment, consisting of a fore part of the lower jaw, containing the cutting-teeth, the eye-tooth, and the two premolars of the right side. The last three teeth are still undeveloped in the jaw, but have been brought into sight by the breaking away of a part of the bone. The remarkable feature of the bone is its size. The development of the teeth is that of a child in its eighth year, while it is cut-

ting its second teeth, but the proportions of the bone and of the teeth are those of a fully-grown person. The measurements of every part largely exceed those of similar parts in any child, and equal, in some points surpass, those of adults. Peculiarities were remarked in the shape of the fragment, as a retrocession of the lower part of the jaw, indicating the absence of a chin, and a very oblique slope of the hinder surface of the symphysis, as is observed in a higher degree in the anthropoids and in a lower degree in savage races and other fossils of men, such as the jaw of Nanette, with which this one has considerable similarity.

An Unpublished Letter of Sir Isaac Newton's.—At the *conversazione* given to Professor Helmholtz at University College, Mr. Latimer Clark exhibited the accompanying interesting unpublished letter from Sir Isaac Newton to Dr. Law:

"LONDON, *December* 15, 1716.

"DEAR DOCTOR: He that in ye mine of knowledge deepest diggeth, hath like every other miner ye least breathing time, and must sometimes at least come to terr; alt for air.

"In one of these respiratory intervals I now sit doune to write to you, my friend.

"You ask me how, with so much study, I manage to retene my health. Ah, my dear doctor, you have a better opinion of your lazy friend than he hath of himself. Morpheous is my best companion; without 8 or 9 hours of him yr correspondent is not worth one scavenger's peruke. My practizes did at ye first hurt my stomach, but now I eat heartily enow as y' will see when I come down beside you.

"I have been much amused by ye singular φενομενα resulting from bringing of a needle into contact with a piece of amber or resin fricated on silke clothe. Ye flame putteth me in mind of sheet lightning on a small—how very small—scale. But I shall in my epistles abjure Philosophy whereof when I come down to Sakly I'll give you enow. I began to scrawl at 5 mins frm 9 of ye clk, and have in writing consmd 10 mins. My Ld. Somerset is announced.

"Farewell, Gd bless you and help yr sincere friend (Signed) ISAAC NEWTON.

"To Dr. Law, Suffolk."

—*Nature.*

The Endowment of Research.—A meeting of the Fellows of the Royal Astronomical Society was lately held to consider the question of the endowment of research, when resolutions were offered by the Earl of Crawford, Sir Edmund Beckett, the Astronomer Royal, Captain Noble, and others, expressing opinions adverse to the granting of public money for scientific research where it does not appear that results useful to the public will be obtained, or where the researches proposed are likely to be undertaken by private individuals or public bodies, as not tending to the real advancement of science; disapproving the foundation of a physical observatory at the national expense; recommending the discontinuance of the Government grant to the Committee on Solar Physics; and calling for the publication of full accounts of all money expended by the Government for scientific purposes, and clear definitions of the nature of the work to be undertaken. The resolutions gave way to an amendment, which was adopted, declaring that no sufficient reason existed at present why the Society, in its corporate capacity, should express an opinion on the subject.

Frost-formed Earth-Beds.—Professor W. C. Kerr contributes to the "American Journal of Science" some observations on the superficial earths which cover the rocks of the Middle and South Atlantic States for a depth of from a few feet to twenty or thirty feet, and sometimes twice as much. The earths are easily discovered to be for the most part the result of the decomposition *in situ* of the exposed edges of the underlying strata, the vertical and highly inclined bedding lines of which are distinctly traceable by the eye through the earth-covering, and are seen to pass by insensible gradations into the undecayed rock beneath. The question is discussed, by what agency, and when, was this decomposition effected. The beds present, generally, unstratified masses of earth, interspersed with pebbles and coarser stones, with a general tendency of the heavier fragments to seek the bottom, or to descend, like a stream, to the lower levels of the formation. Indications of a proper stratification by the action of water are seldom present; and such action is excluded by the most obvious features of the deposits. The appearances point rather to a settling by some kind of movement of the mass. A clew to the origin of the beds is given by the mineral veins which rise to the level of their floors. Fragments of the mineral are thickly scattered around them,

and prove to be identical with the pebbles with which the earth is interspersed. The pebbles, then, originate from the veins, which have been broken up by the same agency that has caused the decomposition of the stratified rock. This agency Professor Kerr believes to have been the action of the frost of the glacial period, which, as we infer from observations made in northern latitudes, may readily have penetrated the rocks to the depth indicated by the character of the beds, and, constituting what might be called an earth-glacier, would have produced the same movements of the mass and of the particles among themselves as are seen to occur in the true glacier, differing only in amount. The deposits might then be called frost-drift, as distinguished from proper glacial drift. Instances of veins in course of actual disintegration are mentioned in the paper. In cutting a hill for the extension of Market Street in Philadelphia, in 1876, bands of hornblende and chlorite were found decomposed, drawn out, and bent over, as if in course of being carried down the slope, and a similar appearance is observable in a mica-mine in Yancey County, North Carolina. The gold-bearing gravels or placers of North Carolina belong to this class of frost-drifts, the gold and quartz pebbles being derived from the veins which have been broken down in the course of their formation.

Burying the Souls of the Drowned.—Whenever an Abchasian is drowned, his friends search carefully for the body; but, if this is not found, they proceed to capture the soul of the deceased, a measure which has then become a matter of importance. A goat-skin bag is sprinkled with water and placed with its mouth, which is stretched open over a hoop, looking toward the river, near to the place where the man is supposed to have been drowned. Two cords are stretched from the spot across the river, as a bridge on which the soul can come over. Vessels containing food and drink are set around the skin, and the friends of the deceased come and eat quietly, while a song is sung with instrumental accompaniments. The soul, it is believed, is attracted by the ceremonies, comes over on the bridge that is laid for it, and goes into the trap. As soon as it has entered—that is, when the bag is inflated by the breeze—the opening is quickly closed, and the bag is taken to the burial-place, where a grave has already been prepared. The bag is held with the opening to the grave, the strings are untied, and the soul—that is, the wind in the bag—is squeezed into the grave, and the burial is afterward completed. This rite is considered of equivalent value with the burial of the body, and the grave is treated with the same honor as if the body were really within it.

Alkaline Deposits from Waters of Irrigation.—Professor E. W. Hilgard, in his report as Professor of Agriculture in the University of California, observing that ordinary surface irrigation on alkaline lands tends to concentrate the alkali at the surface, proposes as a remedy underdraining, "which may so far lower the water-table from which the saline matters are derived, and may so far favor the washing out of the salts during the rainy season, that the latter will thereafter fail to reach the surface so as to accumulate to an injurious extent with reasonable tillage." The waters of Kern and Tulare Lakes contain an excess of solid matter, the quantity in the former lake being twenty-six times as much as in average river-water, and consisting mostly of carbonate of soda, common and Glauber's salts. The evaporation from such water when it is used in irrigation adds annually to the deposit of alkali in the soil, the effect of which must be counteracted by the cultivation of deep-rooted crops, the use of gypsum, sub-irrigation, and the leaching out of the alkali from time to time by long-continued flooding and underdrainage. Professor Hilgard concludes, after an examination of the facts, that "there are, probably, few river-waters in the world of such composition or natural purity that continued irrigation without correlative underdrainage can be practiced without in the end causing an injurious accumulation of soluble salts in the soil." The Indian Government, after having spent enormous sums to bring water upon the fields, now has to face the problem of its economical removal by drainage, so as to relieve the soil of the accumulated alkali which has rendered it unfit for cultivation.

The New Eddystone Lighthouse.—The last coping-stone of the new Eddystone Lighthouse was laid on the 1st of June by the Duke of Edinburgh. The foundation-stone was laid by the same prince as Master of the Trinity Board on August 19, 1879. It is expected that the tower will be ready for the exhibition of the light next March. The new tower is double the height of the old one, and is made of uniform granite. The light, instead of being fixed as at present, will be oscillating, and will consist of a powerful white, double-flashing half-minute light, showing two successive flashes of about two and a half seconds' duration, divided by an eclipse of about four seconds, the second flash being followed by an eclipse of about twenty-one seconds. The light will be visible all around the horizon, for seventeen and a half miles, and will overlap the light of the Lizard, where there are now eight miles of darkness. A subsidiary white light is to be mounted in an upper room, to cover the reef of rocks known as the Hand Deeps, which will be adjusted so as to be seen only within the area of danger occasioned by those rocks.

Sulphur Formation in the Soil of Paris.—M. Daubrée has called attention to a formation of native sulphur which is now going on in the soil of Paris. The mineral has been found in considerable quantities among the rubbish dug up from the Place de la République, presenting a crystalline appearance to the naked eye, and showing under the glass the octahedral forms which are most characteristic of the natural crystals. The origin of this substance, which is found in situations that preclude the supposition of emanations of illuminating gas having anything to do with it, is evidently to be ascribed to the presence of sulphate of lime, old plaster, and various organic matters which have been brought together during the last two centuries in the filling up of the ditch that formerly encircled the city. The sulphur occurs at a depth of from eight or ten inches to ten feet below the surface, and over an area of one hundred and sixty by fifty or sixty feet, forming in reality a kind of bed or deposit of the mineral. Specimens have been obtained from it of workable sulphur, analogous to that of Sicily and other countries, consisting of a breccia of small fragments incrusted with crystals of sulphur, cementing them one to another.

A Vegetable Digestive Agent.—M. Wurtz, in a paper read before the French Academy of Sciences, has drawn general attention to the great chemical and therapeutical value of *papaine*, a vegetable substance which excites the digestive faculty, as opium produces sleep. Both these substances are obtained in the same manner, by cutting into the epidermis of plants whose lactiferous vessels are charged with medical juices. The *Carica papaya*, or common papaw-tree, belongs to the family of the *Cucurbitaceæ*, or gourds; its straight, cylindrical trunk, from ten to sixteen feet high, is terminated at the top by a cluster of large palmate leaves, which give it the appearance of a palm-tree. The fruits, hanging in clusters under the leaves, have the shape of roundish cucumbers, and are much esteemed when ripe. The papaw appears to have originated in the Moluccas, but has been acclimated in India, Mauritius, the Island of Réunion, the Antilles, and a considerable part of South America. The milky juice which contains the papaine is white, slightly bitter, and styptic, free from tartness, has an acid reaction, and is so highly charged with albumen that Vauquelin compared it to blood deprived of its coloring-matter. It flows from incisions made in the bark and the green fruits, and is immediately bottled and sent to market either pure or with the addition of ten or twelve per cent. of alcohol to prevent fermentation. If pure, it comes coagulated; if mixed with alcohol, it remains liquid, and, after standing, separates into a clear liquid and a white precipitate, composed in great part of albumen, fibrine, and a considerable quantity of precipitated papaine. Alcohol precipitates from it crude papaine; this, after being washed in alcohol and ether, to remove fatty matters, is again dissolved in water. The precipitate from this solution is pure papaine, which, when purified by dyalise, has the composition of an albuminoid substance. Papaine, refined with the sub-acetate of lead, offers several distinctive characteristics, among which are: 1. It is very soluble in water, dissolving like a gum; 2. The solution makes a lather

with water; 3. The solution becomes turbid in boiling, without coagulating; when it is curdy it sometimes leaves an insoluble residue in water; left to stand, the solution becomes turbid after some days, and a microscopic examination shows it to be filled with vibriones; 4. In the presence of a saccharine liquid, papaine acts as an alcoholic ferment, with an extraordinary energy and promptitude, but the digestive property may be arrested by the application of benzoic or salicylic acid. The most important property of papaine, and one which puts it in the rank of the most powerful digestive ferments, is its action on meats. One part of papaine will digest and transform into soluble peptone from two hundred and fifty to three hundred parts of meat. Its solubility in different fluids allows it to be used in a great many pharmaceutical forms; and, being a vegetable juice, it can be preserved with more stability than animal ferments, and can be kept indefinitely when dry.

NOTES.

Mr. E. F. Horton gives an account, in the "Kansas City Review," of the opening of a mound thirty or forty feet in diameter, near Trenton, Missouri, June 9th, in which at least twenty-five human skeletons, but no relics or implements, were found. He estimates that the mound has contained from one hundred and fifty to two hundred skeletons, and says: "There appears to have been a stone floor on which the bodies have been placed; over them a stone covering, supported, probably, by stones set edgewise, upon which were other bodies; this continuing until there were four layers of corpses and five layers of stone."

Mr. Gerard Krefft, a naturalist distinguished for his work in the natural history of Australia, died in February last. He was born in Brunswick, Germany, in 1830, early conceived a taste for natural history, and went to Melbourne in 1852, after having spent some time in the United States. He went out in the collecting expedition which was dispatched by the Victorian Government in 1858, became its leader, and supplemented the collection of specimens which he brought back with a full report concerning the animals he obtained, and the manners and habits of the aborigines. Having spent a short time in Europe, he returned to Sydney, and became connected with the Australian Museum, and eventually its curator, till 1874.

The International Geological Congress, which held its first session in Paris, in 1878, will meet at Bologna, Italy, September 26th, under the honorary presidency of Signor Sella. The King of Italy has taken a warm interest in the meeting, and has made considerable efforts to assure its success. A geological exposition will be held during the sessions, and excursions will be made to various points of interest. The reports of the International Committee appointed in 1878, on the unification of geological nomenclature and the conventional signs (figures and colors) used for charts, will soon be mailed to subscribers to the Congress. This question has been made a subject for competitive essays, for which prizes given by King Humbert are to be distributed by a jury.

M. Fievez, of the Brussels Observatory, has produced a new argument against Mr. Lockyer's theory that the spectrum furnishes evidence that some of the terrestrial elements are resolved into simpler constituents by the solar heat. Mr. Lockyer's view is based on the fact that some of the spectral lines of elements are shortened, disappear, or are unequally reversed in solar observation. M. Fievez has found that he can cause two of the lines of hydrogen to disappear, without any change in temperature taking place, by simply reducing the intensity of the light, as when he diminishes the aperture of his instrument during the observation. The lines shorten and go out as the aperture is drawn up; appear and lengthen when it is opened again. Similar results were obtained with the spectra of nitrogen and magnesium; and the phenomena of reversal noticed by Mr. Lockyer were also produced by changing the intensity of the light.

Mr. C. Shaler Smith has applied the results of the observations of several years to the estimation of the amount of pressure that has been exercised by the wind in gusts of extraordinary violence. The most violent storm of which he has a record occurred at East St. Louis, Ill., in 1871, when a locomotive was blown over by a wind-pressure of 93 pounds per square foot. The jail at St. Charles, Mo., was destroyed in 1877, by a pressure of 84·3; a brick dwelling at Marshfield, Mo., in 1880, by a force of 58 pounds per square foot. Railway-trains may be blown from the track, and bridges prostrated by pressures of from 24 to 31 pounds per square foot. These estimates are based upon the calculation of the smallest amount of pressure that would do the damage.

The magnetic survey of Missouri is to be continued during the summer at the expense of a gentleman in St. Louis. The State Legislature has rejected a bill author-

izing the county courts to employ competent persons to fix the north and south lines at the county-seats, at an expense of not more than fifty dollars each.

Recent experiments by Nies and Winkelman indicate that expansion, in passing from the liquid to the solid state, is a more common property of metals than has been believed. Their fundamental experiment consisted in putting the solid metal into the liquid. In some cases the difference in density could be measured. They found that six out of eight metals examined distinctly expanded in solidifying, while the result was obscure in the case of the other two metals. Tin increased in volume 0·7 per cent.; zinc, 0·2 per cent.; bismuth, 3 per cent.; and antimony, iron, and copper in obvious proportions. Lead and cadmium presented difficulties that hindered a satisfactory determination of their qualities.

Kraut has shown that ordinary combustible substances may be set on fire by nitric acid. A wooden box of convenient size was half filled with sawdust, hay, straw, tow, or shavings. A flask containing nitric acid, of at least 1·5 specific gravity, was placed upon this, and the box filled up with the combustible material. The flask was then broken, and a wooden cover was put on the box. Vapors were seen in one or two minutes; a thick, white smoke appeared a little later; and the odor of the burning material was observed. On opening the box a few minutes afterward, the interior was found all on fire, and flames burst out.

M. E. Villari, from experimental measurements of the temperature of the body during acts of motion, has reached the conclusions that the lowest temperature in man, ensuing after a period of rest, is 98·4°; that the temperature increases, under the influence of a positive, ascending effort, to 100·6°, under the influence of a descending effort to 100·3°; that it increases after any exertion, but more after an ascending than after a descending one; and that the chemical actions of the organism are augmented after every movement.

A Sunday Science School at Edinburgh, Scotland, has enrolled ninety-two pupils, and enjoyed an average attendance, from November to July last, of sixty youth who were not able on account of late business hours to attend the evening classes.

M. Pictet recently read a paper before the French Society of Civil Engineers, explaining the operation of his ice-machines, at the close of which he invited the members of the society to visit his works, where two machines are operating with sulphurous acid, one of which produces 2,425 pounds of ice per hour.

The first number of Volume II of "Studies from the Biological Laboratory of John Hopkins University" is just published, and contains among others a lengthy but very interesting article on "The Study of Human Anatomy historically and legally considered."

Mr. Ronald Campbell Gunn, a Tasmanian botanist, died March 14th, aged seventy-three years. He was born at the Cape of Good Hope, and, having removed to Tasmania in 1830, was intrusted with important official positions. He began to investigate the botany and natural history of the island in 1830, and in this occupation rambled over most of the colony. Reports of his work appear in Sir Joseph D. Hooker's "Flora of Tasmania," and in several periodical publications. He was also editor of the "Tasmanian Journal," a scientific publication.

Almost simultaneously with the publication of the discoveries of Messrs. Bell and Tainter in radiophony, M. Mercadier, in Paris, without any knowledge of what they had done, announced that he had been able to reproduce the sounds of speaking and singing upon the photophonic receiver, not only with the light of the sun, but also by means of the electric light, and the oxy-hydrogen light.

Mr. John Blackwall, one of the oldest members of the Linnæan Society, died May 11th, aged ninety-two years. His principal work was a monograph on the British spiders, published by the Ray Society, about twenty years ago. He also published "Researches in Zoölogy," in 1834 (second edition, 1873), and a considerable number of papers on general zoölogy.

A market for the sale of toads to gardeners is held regularly every week in Paris. Dealers bring their "goods" in well-ventilated casks, in which the toads are packed in lots of a hundred, in damp moss. A lot of a hundred good individuals will bring fifteen to seventeen dollars. The gardeners use them to keep down the destructive insects that annoy them. A Dutch gardener, M. Krelage, of Haarlem, recommends the use of the toad in greenhouses, as furnishing an excellent means for destroying the millepeds that infest the plants.

An International Medical and Sanitary Exhibition is to be held under the auspices of the Parkes Museum of Hygiene at South Kensington from July 16th to August 13th. It will comprise everything that is of service for the prevention, detection, cure, and alleviation of disease.

The French Association for the Advancement of Science will meet at Rochelle next year.

JAMES CRAIG WATSON.

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THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

By HERBERT SPENCER.

IX.—REPRESENTATIVE BODIES.

AMID the varieties and complexities of political organization, it has proved not impossible to discern the ways in which simple political heads and compound political heads are evolved; and how, under certain conditions, the two become united as ruler and consultative body. But, to see how a representative body arises, proves to be more difficult; for both process and product are more variable. Less specific results must content us.

As hitherto, so again, we must go back to the beginning to take up the clew. Out of that earliest stage of the savage horde in which there is no supremacy beyond that of the man whose strength, or courage, or cunning, gives him predominance, the first step is to the practice of election—deliberate choice of a leader in war. About the conducting of elections in rude tribes travelers are silent: probably the methods used are various. But we have accounts of elections as they were made by European peoples during early times. In ancient Scandinavia, the chief of a province, chosen by the assembled people, was thereupon "elevated amid the clash of arms and the shouts of the multitude"; and among the ancient Germans he was carried on a shield. Recalling, as this ceremony does, the chairing of a newly elected member of Parliament up to recent times, and reminding us that originally among ourselves election was by show of hands, we are taught that the choice of a representative was once identical with the choice of a chief. Our House of Commons had its roots in local gatherings like those in which uncivilized tribes select head warriors.

Besides conscious selection, there occurs among rude peoples selec-

tion by lot. The Samoans, for instance, by spinning a cocoanut, which on coming to rest points to one of the surrounding persons, thereby single him out. Early historic races supply illustrations; as the Hebrews in the affair of Saul and Jonathan, and as the Homeric Greeks when fixing on a champion to fight with Hector. In both these last cases there was belief in supernatural interference: the lot was supposed to be divinely determined. And probably at the outset, choice by lot for political purposes among the Athenians, and for military purposes among the Romans, as, also, in later times, the use of the lot for choosing deputies in some of the Italian republics, and in Spain (as in Leon during the twelfth century), was influenced by a kindred belief; though doubtless the desire to give equal chances to rich and poor, or else to assign without dispute a mission which was onerous or dangerous, entered into the motive or was even predominant. Here, however, the fact to be noted is, that this mode of choice which plays a part in representation may also be traced back to the usages of primitive peoples.

So, too, we find foreshadowed the process of delegation. Groups of men who open negotiations, or who make their submission, or who send tribute, habitually appoint certain of their number to act on their behalf. The method is, indeed, in such cases necessitated; since a tribe can not well perform such actions bodily. Whence, too, it appears that the appointing of representatives is, at the first stage, originated by causes like those which reoriginate it at a later stage. For, as the will of the tribe, readily displayed in its assemblies to its own members, can not be thus displayed to other tribes, but must, in respect of inter-tribal matters, be communicated by deputy, so, in a large nation, the people of each locality, able to govern themselves locally, but unable to join the peoples of remote localities in deliberations which concern them all, have to send one or more persons to express their will. Distance in both cases changes direct utterance of the popular voice into indirect utterance.

Before observing the conditions under which this singling out of individuals in one or other way for appointed duties comes to be used in the formation of a representative body, we must exclude classes of cases not relevant to our present inquiry. Though representation as ordinarily conceived, and as here to be dealt with, is associated with a popular form of government, yet the connection between them is not a necessary one. In some places and times representation has coexisted with entire exclusion of the masses from power. In Poland, both before and after the so-called republican form was assumed, the central Diet, in addition to senators nominated by the king, was composed of nobles elected in provincial assemblies of nobles: the people at large being powerless and mostly serfs. In Hungary, too, up to recent times, the privileged class, which, even after it had been greatly enlarged, reached only "one twentieth of the adult males," alone

formed the basis of representation. "A Hungarian county before the reforms of 1848 might be called a *direct* aristocratical republic," all members of the noble class having a right to join the local assembly and vote in appointing a representative noble to the general Diet, but the inferior classes having no share in the government.

Other representative bodies than those of an exclusively aristocratic kind must be named as not falling within the scope of this chapter. As Duruy remarks: "Antiquity was not as ignorant as is supposed of the representative system. . . . Each Roman province had its general assemblies. . . . Thus the Lycians possessed a true legislative body formed by the deputies of their twenty-three towns. . . . This assembly had even executive functions." And Pavia, Gaul, Spain, all the eastern provinces, and Greece, had like assemblies. But, little as is known of them, the inference is tolerably safe that these were but distantly allied in genesis and position to the bodies we now distinguish as representative. Nor are we concerned with governing senates and councils elected by different divisions of a town-population, such as those which were variously formed in the Italian republics—bodies which served simply as agents whose doings were subject to the directly-expressed approval or disapproval of the assembled citizens. Here we must limit ourselves to that kind of representation which arises in communities occupying areas so large that their members are obliged to exercise by deputies such powers as they possess; and, further, we have to deal exclusively with cases in which the assembled deputies do not replace preëxisting political agencies, but coöperate with them.

It will be well to set out by observing, more distinctly than we have hitherto done, what part of the primitive political structure it is from which the representative body, as thus conceived, originates.

Broadly, this question is tacitly answered by the contents of the preceding chapters. For, if, on occasions of public deliberation, the primitive horde spontaneously divides into the inferior many and the superior few, among whom some one is most influential; and if, in the course of the compounding and recompounding of groups which war brings about, the recognized war-chief develops into the king, while the superior few become the consultative body formed of minor military leaders—it follows that any third coördinate political power must be either the mass of the inferior itself, or else some agency acting on its behalf. Truism though this may be called, it is needful here to set it down; since, before inquiring under what circumstances the growth of a representative system follows the growth of popular power, we have to recognize the relation between the two.

The undistinguished mass, retaining a latent supremacy in simple societies not yet politically organized, though it is brought under restraint as fast as war establishes submission, and conquests produce

class-differentiations, tends, when occasion permits, to reassert itself. The sentiments and beliefs, organized and transmitted, which, during certain stages of social evolution, lead the many to submit to the few, come, under some circumstances, to be traversed by other sentiments and beliefs. Passing references have been in several places made to these. Here we must consider them *seriatim* and more at length.

One factor in the development of the patriarchal group during the pastoral stage was shown to be the fostering of subordination to its head by war; since, continually, there survived the groups in which subordination was greatest. But, if so, the implication is that, conversely, cessation of war tends to diminish subordination. Members of the compound family, originally living together and fighting together, become less strongly bound in proportion as they have less frequently to coöperate for joint defense under their head. Hence, the more peaceful the state the more independent become the multiplying divisions forming the gens, the phratry, and the tribe. With progress of industrial life arises greater freedom of action—especially among the distantly-related members of the group.

So must it be, too, in a feudally-governed assemblage. While standing quarrels with neighbors are ever leading to local battles; while bodies of men-at-arms are kept ready, and vassals are from time to time summoned to fight; while, as a concomitant of military service, acts of homage are insisted upon—there is maintained a regimental subjection running through the group. But, as fast as aggressions and counter-aggressions become less frequent, the carrying of arms becomes less needful; there is less occasion for the periodic expressions of fealty; and there is a proportionate increase of daily actions carried on without direction of a superior, fostering increased individuality of character.

These changes are furthered by the decline of superstitious beliefs concerning the natures of head-men, general and local. As before shown, the ascription of superhuman origin, or supernatural power, to the king, greatly strengthens his hands; and where the chiefs of component groups have a sacredness due to nearness in blood to the semi-divine ancestor worshiped by all, or are members of an invading, god-descended race, their authority over dependents is largely enforced. By implication, then, anything which undermines ancestor-worship, and the system of beliefs accompanying it, favors the growth of popular power. Doubtless the spread of Christianity over Europe, by diminishing the prestige of governors, major and minor, prepared the way for greater independence of the governed.

These causes have relatively small effects where the people are scattered. In rural districts the authority of political superiors is weakened with comparative slowness. Even after peace has become habitual, and local heads have lost their semi-sacred characters, there cling to them awe-inspiring traditions; they are not of ordinary flesh

and blood. Wealth, which, through long ages, distinguishes the nobleman exclusively, gives him both actual power and the power arising from display. Fixed literally or practically, as the several grades of his inferiors are during days when locomotion is difficult, he long remains for them the solitary sample of a great man : others are known only by hearsay ; he is known by experience. Inspection is easily maintained by him over dependent and sub-dependent people ; and the disrespectful or rebellious, if they can not be punished overtly, can be deprived of occupation, or otherwise so hindered in their lives that they must submit or migrate. Down to our own day, the behavior of peasants and farmers to the squire is suggestive of the strong restraints which kept rural populations in semi-servile states after primitive controlling influences had died away.

Converse effects may be expected under converse conditions, namely, where large numbers become closely aggregated. Even if such large numbers are formed of groups severally subordinate to heads of clans, or to feudal superiors, sundry influences combine to diminish subordination. When there are present in the same place many superiors to whom respectively their dependents owe obedience, these superiors tend to dwarf one another. The power of no one is so imposing if there are daily seen others who make like displays. Further, when groups of dependents are mingled, supervision can not be so well maintained by their heads. And this, which hinders the exercise of control, facilitates combination among those to be controlled ; conspiracy is made easier and detection of it more difficult. Again, jealous of one another, as these heads of clustered groups are likely in such circumstances to be, they are prompted severally to strengthen themselves, and to this end, competing for popularity, are tempted to relax the restraints over their inferiors and to give protection to inferiors ill-used by other heads. Still more are their powers undermined when the assemblage comes to include many aliens. As before implied, this, above all causes, favors the growth of popular power. In proportion as immigrants, detached from the gentile or feudal divisions they severally belong to, become numerous, they weaken the structures of the divisions among which they live. Such organization as these strangers fall into is certain to be a looser one ; and their influence becomes a dissolving agency to the surrounding organizations.

And here we are brought back to the truth which can not be too much insisted upon, that growth of popular power is in all ways associated with trading activities. For only by trading activities can many people be brought to live in close contact. Physical necessities maintain the wide dispersion of a rural population ; while physical necessities impel the gathering together of those who are commercially occupied. Evidence from various countries and times shows that periodic gatherings for religious rites, or other public purposes, furnish opportunities for buying and selling, which are habitually utilized ;

and this connection between the assembling of many people and the exchanging of commodities, which first shows itself at intervals, becomes a permanent connection where many people become permanently assembled—where a town grows up in the neighborhood of a temple, or around a stronghold, or in a place where local circumstances favor some manufacture.

Industrial development further aids popular emancipation by generating an order of men whose power, derived from their wealth, competes with, and begins in some cases to exceed, the power of those who previously were alone wealthy—the men of rank. While this initiates a conflict which diminishes the influence previously exercised by patriarchal or feudal heads only, it also initiates a milder form of subordination. Rising, as the rich trader habitually does in early times, from the non-privileged class, the relation between him and those under him is one from which there is excluded the idea of personal subjection. In proportion as the industrial activities become predominant, they make familiar a connection between employer and employed, which differs from the relation between master and slave, or lord and vassal, by not including allegiance. Under earlier conditions there does not exist the idea of detached individual life—life which neither receives protection from a clan-head or feudal superior nor is carried on in obedience to him. But in town-populations, made up largely of refugees, who either become small traders or are employed by large ones, the experience of a relatively independent life becomes common, and the conception of it distinct.

And the form of coöperation distinctive of the industrial state which thus arises fosters the feelings and thoughts appropriate to popular power. In daily usage there is a balancing of claims; and the conception of equity is, generation after generation, made clearer. The relations between employer and employed, and between buyer and seller, can be maintained only on condition that the obligations on either side are fulfilled. Where they are not fulfilled the relation lapses, and leaves outstanding those relations in which they are fulfilled. Commercial success and growth have thus, as their inevitable concomitants, the maintenance of the respective claims of those concerned, and a strengthening consciousness of them.

In brief, then, dissolving in various ways the old relation of *status*, and substituting the new relation of contract (to use Sir Henry Maine's antithesis), progressing industrialism brings together masses of people who by their circumstances are enabled, and by their discipline prompted, to modify the political organization which militancy has bequeathed.

It is common to speak of free forms of government as having been initiated by happy accidents. Antagonisms between different powers in the state, or different factions, have caused one or other to bid for

popular support, with the result of increasing popular power. The king's jealousy of the aristocracy has induced him to enlist the sympathies of the people—sometimes serfs, but more frequently citizens—and therefore to favor them; or, otherwise, the people have profited by alliance with the aristocracy in resisting royal tyrannies and exactions. Doubtless, the facts admit of being thus presented. With conflict there habitually goes the desire for allies; and throughout mediæval Europe, while the struggles between monarchs and barons were chronic, the support of the towns was important. Germany, France, Spain, Hungary, furnish illustrations.

But it is an error to regard occurrences of these kinds as causes of popular power. They are to be regarded rather as the conditions under which the causes take effect. These incidental weakenings of pre-existing institutions do but furnish opportunities for the action of the pent-up force which is ready to work political changes. Three factors in this force may be distinguished—the relative mass of those composing the industrial communities as distinguished from those embodied in the older forms of organization; the permanent sentiments and ideas produced in them by their mode of life; and the temporary emotions excited by special acts of oppression or by distress. Let us observe the coöperation of these.

Two instances, occurring first in order of time, are furnished by the Athenian democracy. The condition which preceded the Solonian legislation was one of violent dissension among political factions; and there was also "a general mutiny of the poorer population against the rich, resulting from misery combined with oppression." The more extensive diffusion of power, effected by the revolution which Kleisthenes brought about, occurred under kindred circumstances. The relatively-detached population of immigrant traders had so greatly increased between the time of Solon and that of Kleisthenes that the four original tribes forming the population of Attica had to be replaced by ten. And then this augmented mass, largely composed of men not under clan-discipline, and therefore less easily restrained by the ruling classes, forced itself into predominance at a time when the ruling classes were divided. Though it is said that Kleisthenes, "being vanquished in a party contest with his rival, took the people into partnership"—though the change is represented as being one thus personally initiated—yet, in the absence of that voluminous popular will which had long been growing, the political reorganization could not have been made, or, if made, could not have been maintained. The remark which Grote quotes from Aristotle, that "seditions are generated by great causes, but out of small incidents," if altered slightly by writing "political changes" instead of "seditions," fully applies. For clearly, once having been enabled to assert itself, this popular power could not be forthwith excluded. Kleisthenes could not under such circumstances have imposed on so large a mass of men arrangements at vari-

ance with their wishes. Practically, therefore, it was the growing industrial power which then produced, and thereafter preserved, the democratic organization. Turning to Italy, we first note that the establishment of the small republics, referred to in a preceding chapter as having been simultaneous with the decay of imperial power, may here be again referred to more specifically as having been simultaneous with that conflict of authorities which caused this decay. Says Sismondi, "The war of investitures gave wing to this universal spirit of liberty and patriotism in all the municipalities of Lombardy, of Piedmont, Venetia, Romagna, and Tuscany." In other words, while the struggle between emperor and pope absorbed the strength of both, it became possible for the people to assert themselves. And at a later time Florence furnished an instance similar in nature if somewhat different in form.

At the moment when "Florence expelled the Medici, that republic was bandied between three different parties." Savonarola took advantage of this state of affairs to urge that the people should reserve their power to themselves, and exercise it by a council. His proposition was agreed to, and this "council was declared sovereign, on the 1st of July, 1495."

In the case of Spain, again, popular power increased during the troubles accompanying the minority of Fernando IV; and of the periodic assemblies subsequently formed by deputies from certain towns (which met without authority of the government) we read that—

The desire of the Government to frustrate the aspiring schemes of the Infantes de la Cerda, and their numerous adherents, made the attachment of these assemblies indispensable. The disputes during the minority of Alfonso XI more than ever favored the pretensions of the third estate. Each of the candidates for the regency paid assiduous court to the municipal authorities, in the hope of obtaining the necessary suffrages.

And how all this was consequent on industrial development appears in the facts that many, if not most, of these associated towns had arisen during a preceding age by the recolonization of regions desolated during the prolonged contests of Moors and Christians; and that these *poblaciones*, or communities of colonists, which, scattered over these vast tracts, grew into prosperous towns, had been formed of serfs and artisans to whom various privileges, including those of self-government, were given by royal charter. With which several examples must be joined the example familiar to all. For it was during the struggle between king and barons, when the factions were nearly balanced, and when the town-populations had been by trade so far increased that their aid was important, that they came to play a noticeable part, first as allies in war and afterward as sharers in government. It can not be doubted that, when summoning to the Parliament of 1265 not only knights of the shire but also deputies from cities and boroughs, Simon de Montfort was prompted by the desire to strengthen

himself against the royal party supported by the Pope. And whether he sought thus to increase his adherents or to obtain larger pecuniary means, or both, the implication equally is that the urban populations had become a relatively important part of the nation. This interpretation harmonizes with subsequent events. For, though the representation of towns afterward lapsed, yet it shortly revived, and in 1295 became established. As Hume remarks, such an institution could not "have attained to so vigorous a growth and have flourished in the midst of such tempests and convulsions," unless it had been one "for which the general state of things had already prepared the nation"; the truth here to be added being that this "general state of things" was the augmented mass, and consequently augmented influence, of the free industrial communities.

Confirmation is supplied by cases showing that power, gained by the people during times when the regal and aristocratic powers are diminished by dissension, is lost again if, while the old organization recovers its stability and activity, industrial growth does not make proportionate progress. Spain, or more strictly Castile, yields an example. Such share in government as was acquired by those industrial communities which grew up during the colonization of the waste lands became, in the space of a few reigns, characterized by wars and consolidations, scarcely more than nominal.

It is instructive to note how that primary incentive to coöperation which initiates social union at large continues afterward to initiate special unions within the general union. For, just as external militancy sets up and carries on the organization of the whole, so does internal militancy set up and carry on the organization of the parts, even when those parts, industrial in their activities, are intrinsically non-militant. On looking into their histories we find that the increasing clusters of people who, forming towns, lead lives essentially distinguished by continuous exchange of services under agreement, develop their governmental structures during their chronic antagonisms with the surrounding militant clusters.

We see, first, that these settlements of traders, growing important and obtaining royal charters, were by doing this placed in quasi-militant positions—became in modified ways holders of fiefs from their king, and had the associated responsibilities. Habitually they paid dues of sundry kinds equivalent in general nature to those paid by feudal tenants; and, like them, they were liable to military service. In Spanish chartered towns "this was absolutely due from every inhabitant"; and "every man of a certain property was bound to serve on horseback or pay a fixed sum." In France "in the charters of incorporation which towns received, the number of troops required was usually expressed." And in the chartered royal burghs of Scotland "every burgess was a direct vassal of the crown."

Next observe that industrial towns, usually formed by coalescence of preëxisting rural divisions rendered populous because local circumstances favored some form of trade, and presently becoming places of hiding for fugitives, and of security for escaped serfs, began to stand toward the small feudally-governed groups around them in relations like those in which these stood to one another: competing with them for adherents, and often fortifying themselves.

Again, there is the fact that these cities and boroughs, which by royal charter or otherwise had acquired powers of administering their own affairs, habitually formed within themselves combinations for protective purposes. In England, in Spain, in France, in Germany—sometimes with assent of the king, sometimes notwithstanding his reluctance as in England, sometimes in defiance of him, as in ancient Holland—there rose up guilds, which, having their roots in quasi-religious unions among related persons, presently gave origin to frith-guilds and merchant-guilds; and these, defensive in their relations to one another, formed the basis of that municipal organization which carried on the general defense against aggressing nobles.

Then there is the further fact that, in countries where the antagonisms between these industrial communities and the surrounding militant communities were violent and chronic, the industrial communities combined to defend themselves. In Spain, the *poblaciones*, which when they flourished and grew into large towns were invaded and robbed by adjacent feudal lords, formed leagues for mutual protection; and again, at a later date, there arose under like needs, more extensive confederations of cities and towns, which, under severe penalties for non-fulfillment of the obligations, bound themselves to aid one another in resisting aggressions, whether by king or nobles. In Germany, too, we have the perpetual alliance entered into by sixty towns on the Rhine in 1255, when, during the troubles that followed the deposition of the Emperor Frederick II., the tyranny of the nobles had become insupportable. And we have the kindred unions formed under like incentives in Holland. So that, both in small and in large ways, the industrial groups here and there growing up within a nation are, in many cases, forced by local antagonisms partially to assume activities and structures like those which the nation as a whole is forced to assume in its antagonisms with nations around.

Here the implication chiefly concerning us is that, if industrialism is thus checked by a return to militancy, the growth of popular power is arrested. Especially where, as happened in the Italian republics, defensive war passes into offensive war, and there grows up an ambition to conquer other territories and towns, the free form of government proper to industrial life becomes qualified by, if it does not revert to, the coercive form accompanying militant life. Or where, as happened in Spain, the feuds between towns and nobles continue through long periods, the rise of free institutions is arrested; since,

under such conditions, these can be neither that commercial prosperity which produces large urban populations, nor cultivation of the associated mental nature. Whence it may be inferred that the growth of popular power accompanying industrial growth in England was largely due to the comparatively small amount of this warfare between the industrial groups and the feudal groups around them. The effects of the trading life were less interfered with, and the local governing centers, urban and rural, were not prevented from uniting to restrain the general center.

And now let us consider more specifically how the governmental influence of the people is acquired. By the histories of organizations of whatever kind, we are shown that the purpose originally subserved by some arrangement is not always the purpose eventually subserved. It is so here. Assent to obligations rather than assertion of rights has ordinarily initiated the increase of popular power. Even the transformation effected by the revolution of Kleisthenes at Athens took the form of a redistribution of tribes and demes for purposes of taxation and military service. In Rome, too, that enlargement of the oligarchy which occurred under Servius Tullius had for its ostensible motive the imposing on plebeians of obligations which up to that time had been borne exclusively by patricians. But we shall best understand this primitive relation between duty and power, in which the duty is original and the power derived, by going back once more to the beginning.

For when we remember that the primitive political assembly is essentially a war-council, formed of leaders who debate in presence of armed followers; and when we remember that in early stages all free adult males, being warriors, are called on to join in defensive or offensive actions—we see that, originally, the attendance of the armed freemen is in pursuance of the military service to which they are bound, and that such power as, when thus assembled, they exercise, is incidental. Later stages yield clear proofs that this is the normal order; for it recurs where, after a political dissolution, political organization begins *de novo*. Instance the Italian cities, in which, as we have seen, the original "parliaments," summoned for defense by the tocsin, included all the men capable of bearing arms: the obligation to fight coming first, and the right to vote coming second. And, naturally, this duty of attendance survives when the primitive assemblage assumes other functions than those of a militant kind; as witness the before-named fact that among the Scandinavians it was "disreputable for freemen not to attend" the annual assembly; and the further facts that in France the obligation to attend the hundred-court in the Merovingian period rested upon all full freemen; that in the Carlovingian period, the "non-attendance is punished by fines and amercements"; that in England the lower freemen, as well as others,

were "bound to attend the shire-moot and hundred-moot" under penalty of "large fines for neglect of duty"; and that in the thirteenth century in Holland, when the burghers were assembled for public purposes, judicial or other, "any one ringing the town bell except by general consent, and any one not appearing when it tolls, are liable to a fine."

After recognizing this primitive relation between popular duty and popular power, we shall more clearly understand the relation as it reappears when popular power begins to revive along with the growth of industrialism. For here again the fact meets us that the obligation is primary and the power secondary. It is mainly as furnishing aid to the ruler, generally for war purposes, that the deputies from towns begin to share in public affairs. There recurs under a complex form that which at an early stage we see in a simple form. Let us pause for a moment to observe the transition.

As was shown when treating of "Ceremonial Institutions," the revenues of rulers are derived, at first wholly and afterward partially, from presents. Beginning as irregular and voluntary, the making of presents grows periodic and more or less compulsory. The occasions on which assemblies are called together to discuss public affairs (mainly military operations for which supplies are needed) naturally become the occasions on which the expected gifts are offered and received. When by successful wars the militant king consolidates small societies into a large one—when there comes an "increase of royal power in intension as the kingdom increases in extension" (to quote the luminous expression of Professor Stubbs); and when, as a consequence, the quasi-voluntary gifts become more and more compulsory, though still retaining such names as *donum* and *auxilium*—it generally happens that these exactions, passing a bearable limit, lead to resistance: at first passive and in extreme cases active. If by consequent disturbances the royal power is much weakened, the restoration of order, if it takes place, is likely to take place on the understanding that, with such modifications as may be needful, the primitive system of voluntary gifts shall be reëstablished. Thus, when in Spain the death of Sancho I was followed by political dissensions, the deputies from thirty-two places, who assembled at Valladolid, decided that demands made by the king beyond the customary dues should be answered by death of the messenger; and the need for gaining the adhesion of the towns during the conflict with a pretender led to an apparent toleration of this attitude. Similarly in the next century, during disputes as to the regency while Alfonso XI was a minor, the Cortes at Burgos demanded that the towns should "contribute nothing beyond what was prescribed in" their charters. Kindred causes wrought kindred results in France; as when, by an insurrectionary league, Louis Hutin was obliged to grant charters to the nobles and burgesses of Picardy and of Normandy, renouncing the right of

imposing undue exactions; and as when, on sundry occasions, the States-General was assembled for the purpose of reconciling the nation to imposts levied to carry on wars. Nor must its familiarity cause us to omit the instance furnished by our own history, when, after preliminary steps toward that end at St. Alban's and St. Edmund's, nobles and people at Runnymede effectually restrained the king from various tyrannies, and, among others, from that of imposing taxes without the consent of his subjects.

And now what followed from arrangements which, with modifications due to local conditions, were arrived at in several countries under similar circumstances? Evidently, when the king, hindered from enforcing unauthorized demands, had to obtain supplies by asking his subjects, or the more powerful of them, his motive for summoning them, or their representatives, became primarily that of getting these supplies. The predominance of this motive for calling together national assemblies may be inferred from its predominance, previously shown in connection with local assemblies; as instance a writ of Henry I concerning shire-moots, in which, professing to restore ancient custom, he says: "I will cause those courts to be summoned when I will for my own sovereign necessity, at my pleasure." To vote money is therefore the primary purpose for which chief men and representatives are assembled.

From the ability to prescribe conditions under which money will be voted, grows the ability, and finally the right, to join in legislation. This connection is vaguely typified in early stages of social evolution. Making gifts and getting redress go together from the beginning. As was said of Gulab Singh, when treating of presents, "even in a crowd one could catch his eye by holding up a rupee and crying out, 'Maharajah, a petition.' He would pounce down like a hawk on the money, and, having appropriated it, would patiently hear out the petitioner." I have in the same place given further examples of this relation between yielding support to the governing agency and demanding protection from it; and the examples there given may be enforced by such others as that, among ourselves in early days, "the king's court itself, though the supreme judicature of the kingdom, was open to none that brought not presents to the king," and that, as shown by the exchequer rolls, every remedy for a grievance or security against aggression had to be paid for by a bribe; a state of things which, as Hume remarks, was paralleled on the Continent.

Such being the primitive connection between support of the political head and protection by the political head, the interpretation of the actions of parliamentary bodies, when they arise, becomes clear. Just as, in rude assemblies of king, military chiefs, and armed freemen, preserving in large measure the original form, as those in France during the Merovingian period, the presentation of

gifts went along with the transaction of public business, judicial as well as military—just as, in our own ancient shire-moot, local government, including the administration of justice, was accompanied by the furnishing of ships and the payment of "a composition for the feorm-fultum, or sustentation of the king"—so when, with successful resistance to excess of royal power, there came assemblies of nobles and representatives summoned by the king, there reappeared on a higher platform these simultaneous demands for money on the one side and for justice on the other. We may assume it as certain that, with an average humanity, the conflicting egoisms of those concerned will be the main factors; and that on each side the aim will be to give as little, and get as much, as circumstances allow. France, Spain, and England yield examples which unite in showing this.

When Charles V of France, in 1357, dismissing the States-General for alleged encroachments on his rights, raised money by further debasing the coinage, and caused a sedition in Paris which endangered his life, there was, three months later, a reconvocation of the states, in which the petitions of the former assembly were acceded to, while a subsidy for war purposes was voted. And, of an assembled States-General in 1366, Hallam writes, "The necessity of restoring the coin is strongly represented as the grand condition upon which they consented to tax the people, who had been long defrauded by the base money of Philip the Fair and his successors." Again, in Spain the incorporated towns, made liable by their charters only for certain payments and services, had continually to resist unauthorized demands; while the kings, continually promising not to take more than their legal and customary dues, were continually breaking their promises. In 1328 Alfonso XI "bound himself not to exact from his people, or cause them to pay, any tax, either partial or general, not hitherto established by law, without the previous grant of all the deputies convened to the Cortes." And how little such pledges were regarded is shown by the fact that, in 1393, the Cortes who made a grant to Henry III annexed the condition that—

> he should swear before one of the archbishops not to take or demand any money, service, or loan, or anything else of the cities and towns, nor of individuals belonging to them, on any pretense of necessity, until the three estates of the kingdom should first be duly summoned and assembled in Cortes according to ancient usage.

Similarly in England during the time when parliamentary power was being established. While, with national consolidation, the royal authority had been approaching to absoluteness, there had been, by reaction, arising that resistance which, resulting in the Charter, subsequently initiated the prolonged struggle between the king trying to break through its restraints and his subjects trying to maintain and strengthen them. The twelfth article of the Charter having

promised that no scutage or aid, save those which were established, should be imposed without consent of the national council, there perpetually recurred, both before and after the expansion of Parliament, endeavors on the king's part to get supplies without redressing grievances, and endeavors on the part of Parliament to make the voting of supplies contingent on fulfillment of promises to redress grievances.

On the issue of this struggle depended the establishment of popular power, as we are shown by comparing the histories of the French and Spanish Parliaments with that of the English Parliament. Quotations above given prove that the Cortes originally established, and for a time maintained, the right to comply with or to refuse the king's requests for money, and to impose their conditions; but they eventually failed to get their conditions fulfilled.

In the struggling condition of Spanish liberty under Charles I, the Crown began to neglect answering the petitions of Cortes, or to use unsatisfactory generalities of expression. This gave rise to many remonstrances. The deputies insisted, in 1523, on having answers before they granted money. They repeated the same contention in 1525, and obtained a general law, inserted in the Recopilacion, enacting that the king should answer all their petitions before he dissolved the assembly. This, however, was disregarded as before.

And thereafter rapidly went on the decay of parliamentary power. Different in form, but the same in nature, was the change which occurred in France. Having at one time, as shown above, made the granting of money conditional on the obtainment of justice, the States-General was induced to surrender its restraining powers. Charles VII

obtained from the states of the royal domains which met in 1439 that they [the tailles] should be declared permanent, and from 1444 he levied them as such—i. e., uninterruptedly and without previous vote. . . . The permanence of the tailles was extended to the provinces annexed to the crown, but these preserved the right of voting them by their provincial states. . . . In the hands of Charles VII and Louis XI the royal impost tended to be freed from all control. . . . Its amount increased more and more.

Whence, as related by Dareste, it resulted that, "when the *tailles* and *aides* . . . had been made permanent, the convocation of the States-General ceased to be necessary. They were little more than show assemblies." But, in our own case, during the century succeeding the final establishment of Parliament, continued struggles necessitated by royal evasions, trickeries, and falsehoods, brought an increasing power to withhold supplies until petitions had been attended to.

Admitting that this issue was furthered by the conflicts of political factions, which diminished the coercive power of the king, the truth to be emphasized is that the increase of a free industrial popula-

tion was its fundamental cause. The calling together knights of the shire, representing the class of small land-owners, which preceded on several occasions the calling together deputies from towns, implied the growing importance of this class as one from which money was to be raised; and, when deputies from towns were summoned to the Parliament of 1295, the form of summons shows that the motive was to get pecuniary aid from portions of the population which had become relatively considerable and rich. Already the king had on more than one occasion sent special agents to shires and boroughs to obtain subsidies from them for his wars. Already he had assembled provincial councils formed of representatives from cities, boroughs, and market-towns, that he might get from them votes of money. And, when the great Parliament was called together, the reason set forth in the writs was, that wars with Wales, Scotland, and France, were endangering the realm; the implication being that the necessity for obtaining supplies led to this recognition of the towns as well as the counties.

So, too, was it in Scotland. The first known occasion on which representatives from burghs entered into political action was when there was urgent need for pecuniary help from all sources—namely, "at Cambuskenneth, on the 15th day of July, 1326, when Bruce claimed from his people a revenue to meet the expenses of his glorious war and the necessities of the state, which was granted to the monarch by the earls, barons, burgesses, and free tenants, in full Parliament assembled."

In which cases, while we are again shown that the obligation is original, and the power derived, we are also shown that it is the increasing mass of those who carry on life by voluntary coöperation instead of compulsory coöperation—partly the rural class of small freeholders, and still more the urban class of traders—which initiates popular representation.

Still there remains the question, How does the representative body become separate from the consultative body? Retaining the primitive character of councils of war, national assemblies are at first mixed. The different "arms," as the estates were called in Spain, form a single body. Knights of the shire, when first summoned, acting on behalf of numerous smaller tenants of the king, owing military service, sit and vote with the greater tenants. Standing, as towns originally do, very much in the position of fiefs, those who represent them are not unallied, in legal *status*, to feudal chiefs; and, at first assembling with these, in some cases remain united with them, as appears to have been habitually the case in France and Spain. Under what circumstances, then, do the consultative and representative bodies differentiate? The question is one to which there seems to be no very satisfactory answer.

Quite early we may see foreshadowed a tendency to part, determined by unlikeness of functions. In the Carlovingian period in France there were two annual gatherings: a larger, which all the armed freemen had a right to attend; and a smaller, formed of the greater personages and deliberating on more special affairs.

If the weather was fine, all this passed in the open air; if not, in distinct buildings. . . . When the lay and ecclesiastical lords were . . . separated from the multitude, it remained in their option to sit together, or separately, according to the affairs of which they had to treat.

And that unlikeness of functions is the cause of separation we find evidence in other places and times. Describing the armed national assemblies of the Hungarians, originally mixed, Lévy writes: "La dernière réunion de ce genre eut lieu quelque temps avant la bataille de Mohacs; mais bientôt après, la diète se divisa en deux chambres: la table des magnats et la table des députés." In Scotland, again, in 1367–'68, the three estates having met, and wishing, for reasons of economy and convenience, to be excused from their functions as soon as possible, "elected certain persons to hold parliament, who were divided into two bodies, one for the general affairs of the king and kingdom, and another, a smaller division, for acting as judges upon appeals." In the case of England we find that though, in the writs calling together Simon de Montfort's Parliament, no distinction was made between magnates and deputies, yet when, a generation after, Parliament became established, the writs made a distinction, "counsel is deliberately mentioned in the invitation to the magnates, action and consent in the invitation to representatives." Indeed, it is clear that since the earlier-formed body of magnates was habitually summoned for consultative purposes, especially military, while the representatives afterward added were summoned only to grant money, there existed from the outset a cause for separation. Sundry influences conspired to produce it. Difference of language, still to a considerable extent persisting and impeding joint debate, furnished a reason. Then there was the effect of class-feeling, of which we have definite proof. Though in the same assembly, the deputies from boroughs "sat apart both from the barons and knights, who disdained to mix with such mean personages"; and probably these deputies themselves, little at ease in presence of imposing superiors, preferred sitting separately. Moreover, it was customary for the several estates to submit to taxes in different proportions; and this tended to entail consultation among the members of each body by themselves. Finally, we read that "after they (the deputies) had given their consent to the taxes required of them, their business being then finished, they separated, even though the Parliament still continued to sit, and to canvass the national business." In which last fact we are clearly shown that, though aided by other causes, unlikeness of duties was the essential cause which at length

produced a permanent separation between the representative body and the consultative body.

Thus at first of little account, and growing in power only because the free portion of the community occupied in production and distribution grew in mass and importance, so that its petitions, treated with increasing respect and more frequently yielded to, began to originate legislation, the representative body came to be that part of the governing agency which more and more expresses the sentiments and ideas of industrialism. While the monarch and upper house are the products of that ancient *régime* of compulsory coöperation, the spirit of which they still manifest, though in decreasing degrees, the lower house is the product of that modern *régime* of voluntary coöperation which is replacing it; and in an increasing degree this lower house carries out the wishes of people habituated to a daily life regulated by contract instead of by *status*.

To prevent misconception, it must be remarked before summing up, that an account of representative bodies which have been in modern days all at once created is not here called for. Colonial Legislatures, consciously framed in conformity with traditions brought from the mother-country, illustrate the genesis of senatorial and representative bodies in but a restricted sense; showing, as they do, how the structures of parent societies reproduce themselves in derived societies, so far as materials and circumstances allow; but not showing how these structures were originated. Still less need we notice those cases in which, after revolutions, peoples who have lived under despotisms are led by imitation suddenly to establish representative bodies. Here we are concerned only with the gradual evolution of such bodies.

Originally supreme, though passive, the third element in the triune political structure, subjected more and more as militant activity develops its appropriate organization, begins to reacquire power when war ceases to be chronic. Subordination relaxes as fast as it becomes less imperative. Awe of the ruler, local or general, and accompanying manifestations of fealty, decrease; and especially so where the *prestige* of supernatural origin dies out. Where the life is rural, the old relations long survive in qualified forms; but clans or feudal groups clustered together in towns, mingled with numbers of unattached immigrants, become in various ways less controllable; while by their habits their members are educated to increasing independence. The small industrial groups, thus growing up within a nation consolidated and organized by militancy, can but gradually diverge in nature from the rest. For a long time they remain partially militant in their structures and in their relations to other parts of the community. At first chartered towns stand substantially on the footing of fiefs, paying feudal dues and owing military service. They form within themselves unions, more or less coercive in character, for mutual protection. They often

carry on wars with adjacent nobles and with one another. They not uncommonly form leagues for joint defense. And, where this semi-militancy of towns is maintained, industrial development and accompanying increase of popular power are arrested.

But, where circumstances have favored manufacturing and commercial activities and growth of the population devoted to them, this, as it becomes a large component of the society, makes its influence felt. The primary obligation to render money and service to the head of the state, often reluctantly complied with, is resisted when the exactions are great; and resistance causes conciliatory measures. There comes asking consent rather than resort to compulsion. If absence of violent local antagonisms permits, then on occasions when the political head, rousing anger by injustice, is also weakened by defections, there comes coöperation with other classes of oppressed subjects. Men originally delegated simply that they may authorize imposed burdens are enabled, as the power behind them increases, more and more firmly to insist on conditions; and the growing practice of yielding to their petitions, as a means to obtaining their aid, initiates the practice of letting them share in legislation.

Finally, in virtue of the general law of organization that difference of functions entails differentiation and division of the parts performing them, there comes a separation. At first summoned to the national assembly for purposes partially like and partially unlike those of its other members, the elected members show a segregating tendency, which, where the industrial portion of the community continues to gain power, ends in the formation of a representative body distinct from the original consultative body.

PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

I.—REMEDIAL EDUCATION.

"We can not buy health; we must deserve it."—Francis Bichat.

"PREVENTION is better than cure and far cheaper," said John Locke, two hundred years ago; and the history of medical science has since made it more and more probable that, in a stricter sense of the word, prevention is the only possible cure. By observing the health laws of Nature, a sound constitution can be very easily preserved, but, if a violation of those laws has brought on a disease, all we can do by way of "curing" that disease is to remove the cause; in other words, to *prevent* the continued operation of the predisposing circumstances.

Suppressing the symptoms in any other way means only to change the form of the disease, or to postpone its crisis. Thus, mercurial salves will cleanse the skin by driving the ulcers from the surface to the interior of the body; opiates stop a flux only by paralyzing the bowels—i. e., turning their morbid activity into a morbid inactivity; the symptoms of pneumonia can be suppressed by bleeding the patient till the exhausted system has to postpone the crisis of the disease. This process, the "breaking up of a sickness," in the language of the old-school allopathists, is therefore in reality only an interrupting of it, a temporary interruption of the symptoms. We might as well try to cure the sleepiness of a weary child by pinching its eyelids, or the hunger of a whining dog by compressing his throat.

Drugs are not wholly useless. If my life depended upon a job of work that had to be finished before morning, and the inclination to fall asleep was getting irresistible, I should not hesitate to defy Nature, and keep myself awake with cup after cupful of strong black coffee. If I were afflicted with a sore, spreading rapidly from my temple toward my nose, I should suppress it by the shortest process, even by deliberately producing a larger sore elsewhere, rather than let the smaller one destroy my eyesight. There are also two or three forms of disease which have (thus far) resisted all unmedicinal cures, and can hardly be trusted to the healing powers of Nature—the *lues venerea*, scabies, and prurigo—because, as Claude Bernard suggests, their symptoms are probably due to the agency of microscopic parasites, which oppose to the action of the vital forces a life-energy of their own, or, as Dr. Jennings puts it, "because art has here to interfere—not for the purpose of breaking up diseased action, but for the removal of the cause of that action, the destruction of an active virus that possesses the power of self-perpetuation beyond the dislodging ability of Nature."

But with those rare exceptions it is better to direct our efforts against the cause rather than the symptoms—i. e., in about ninety-nine cases out of a hundred it is not only the safer but also the shorter way to avoid drugs, reform our habits, and, for the rest, let Nature have her course; for, properly speaking, disease itself is a reconstructive process, an expulsive effort, whose interruption compels Nature to do double work; to resume her operations against the ailment after expelling a worse enemy—the drug. If a drugged patient recovers, the true explanation is that his constitution was strong enough to overcome both the disease and the druggist.

Dr. Isaac Jennings,* the greatest pathologist (or, at least, pathognomist) of our century, was sadly misunderstood, chiefly, I believe, because he called his method the "Let-alone Plan." Prevention Plan, or Unmedicinal Cure, would have been a better word. Diseases do not want to be let alone; they call loudly for relief—not, though,

* Author of the "Treatise on Medical Reform."

from their own symptoms, which, in fact, are so many alarm-signals, but from the obstacle which has forced the vital process to deviate from its normal course. Pain, in all its forms, is an appeal for help, and the urgency of the appeal corresponds to the degree of the distress; probably, also, to the possibility of relieving that distress. A deadly blow stuns—the vital forces yield without a struggle. The last stage of pulmonary consumption is a comparatively painless *deliquium*—when a conflagration grows uncontrollable, the alarm-bells cease to ring. Yellow-fever doctors give up their patients for lost when the burning headache changes into a lethargic stupor. The last sensations of drowning, strangled, and freezing persons are said to be rather pleasurable than otherwise. In certain cases the appeal for help continues into an apparently hopeless stage of the disease. Apparently, I say: Nature is too practical to waste her efforts on a forlorn hope; her resistance yields to necessity; and, when the art of healing shall devote itself to the exegesis of disease rather than to the exorcism of its symptoms, that rule will probably be found to apply to pathology as well as to chemistry and ethics.

All bodily ailments are more or less urgent appeals for help; nor can we doubt in what that help should consist. The more fully we understand the nature of any disease, the more clearly we see that the discovery of the cause means the discovery of the cure. Many sicknesses are caused by poisons, foisted upon the system under the name of tonic beverages or remedial drugs; the only cure is to eschew the poison. Others, by habits more or less at variance with the health laws of Nature; to cure such we have to reform our habits. There is nothing accidental, and rarely anything inevitable, about a disease; we can safely assume that nine out of ten complaints have been caused and can be cured by the sufferers (or their nurses) themselves. "God made man upright"; every prostrating malady is a deviation from the state of Nature. The infant, "mewling and puking in its nurse's arms," is an abnormal phenomenon. Infancy should be a period of exceptional health; the young of other creatures are healthier, as well as prettier, purer, and merrier, than the adults, yet the childhood years of the human animal are the years of sorest sickliness; statistics show that among the Caucasian races men of thirty have more hope to reach a good old age than a new-born child has to reach the end of its second year. The reason is this: the health theories of the average Christian man and woman are so egregiously wrong, that only the opposition of their better instincts helps them—against their conscience, as it were—to maintain the struggle for a tolerable existence with anything like success, while the helpless infant has to conform to those theories—with the above results.

"I have long ceased to doubt," says Dr. Schrodt, "that, apart from the effects of wounds, the chances of health or disease are in our own hands; and, if people knew only half the facts point-

ing that way, they would feel *ashamed* to be sick, or to have sick children."

A vestige of the hygienic insight which in savages appears to be a gift of Nature, would, indeed, almost obviate the necessity of a treatise on the diseases of infancy; nay, wherever people have got rid of four or five of the grossest physiological prejudices, the art of preserving the health of a healthy-born child is even now a sort of intuition with every true mother; but nurses, physicians, and foster-parents, are often called upon to mend the mistakes of their predecessors, and to undertake a task whose less intuitive duties may be facilitated by some of the following hints on remedial education:

Shakespeare's "mewling and puking" representative of babyhood was probably overfed. The representative nurse believes in cramming; babies, like prize-pigs, are most admired when they are ready to die with fatty degeneration. The child is coaxed to suckle almost every half-hour, day after day, till habit begets a morbid appetite, analogous to the dyspeptic's stomach distress which no food can relieve till over-repletion brings on a sort of gastric lethargy.

"Many hand-fed infants, weighing about ten pounds, will swallow one and a half quart of cow's milk in one day," says Dr. Page;* "now, considering the needs of a moderately working man to be equal in proportion to size, a man weighing one hundred and fifty pounds should take fifteen times the quantity swallowed by the infant, or twenty-two and a half quarts—a quart for nearly every hour of the day and night!"

Vomiting, restlessness, and gross fatness, are some of the symptoms of the surfeit-disease, and its proper cure is—not soothing-sirups, but—fasting. Four nursings a day are enough, five more than enough, and the ejection of milk after suckling is a sure sign that the quantity given at each meal should be diminished. A pint of milk a day is about as much as a dyspeptic infant can really digest, and to cram it merely in order to stop its crying is quite mistaking the cause of its restlessness; a half-starved child will not cry, because the languor of insufficient nutrition is a pleasure compared with the gastric torments of the surfeit-disease. Children actually perishing with hunger will utter from time to time a peculiar sharp cry, almost like the call of a hungry nest-bird, but the first mouthful of food makes them relapse into a sort of dreamy silence.

There are nurslings who get at least four times more milk and pap than they can possibly assimilate, and whose digestive organs have to reject the surplus in a way that would make life intolerable to an adult, though most nurses seem to consider retching and "dripping" as a normal phase of infant life.

Drugs only complicate the disorder: many children whose constitution would have resisted the cramming process succumb to opiates, "surfeit-water" and ipecacuanha; but, unless foul dormitories still fur-

* "How to feed a Baby to make it healthy and happy," p. 23.

ther aggravate the evil, each night generally undoes the mischief of the day; the child becomes plethoric with fat; Nature has shifted the burden from the vital organs to the tegumental tissues, and in hopes of final relief manages to hold the fort of life against daily and complicated attacks. Relief comes at last when the nursling is weaned and reduced from ten or twelve to three meals a day. The after-effects of medication may retard recovery for a while, but, the main cause being removed, the morbid symptoms disappear in the course of four or five months.

A less frequent but (through gross maltreatment) often more dangerous disease is scrofula, the cachectic degeneration of the humors resulting from the combined influence of unwholesome food and foul air. In the rural districts of our milk and corn-bread States scrofulous children are as rare as white wolves in the tropics; in Northern Europe the disease is now far less prevalent than formerly; and the operatives of our large cities, in spite of their wretched habitations, might avoid it altogether, or at least obviate its more serious consequences, but for the fatuous quackery which so often turns a transient skin-disease into a chronic lung-complaint. In the middle ages, when science was at its lowest ebb and supernaturalism in full tide, the "king's-evil" was considered an almost unavoidable disease, resisting all common remedies and yielding only to the mandate of royalty—the touch of a legitimate king, supplemented by the mandamus of a clerical exorcist. In the fifteenth century from eight to twelve thousand families per year performed long journeys to the English capital; Charles II, in the course of his reign, touched near a hundred thousand persons. The days on which the miracle was to be wrought were solemnly notified by the clergy of all parish churches (Macaulay's "History of England," Chapter XIV). Traveling was expensive in those days, and, scrofula being distinctively a disease of the poor, nine out of ten patients of the royal doctor had probably come afoot, and often from distances which suggest the explanation of the marvelous cures: the pilgrims left the pest-air of their hovels behind, and Nature availed herself of the respite, as she improves a temporary change from city fumes to the woodland air of some rural retreat whose salubriousness is ascribed to the accidental presence of a nauseous sulphur-spring—the one abnormal thing about the place. The king's-evil patients, as well as the exorcists, ascribed the cure to what Dr. Joel Brown called the *charisma basilicon*—the healing touch of the Lord's anointed—in other words, they believed that the cure of a Yorkshire man's disease depended upon the chance of the Yorkshire man's coming in contact with a Londoner who, perhaps ten or twenty years ago, had undergone the rites of a certain ceremony. Imagination probably helped a little, for after the spread of skepticism "perfect cures became much less frequent," as Dr. Brown naïvely remarks. The *charisma basilicon* has now fallen into utter discredit, but our

present method is so little of an improvement that the patients of a future century would probably prefer to resume the Whitehall pilgrimages. Instead of ventilating our houses and abolishing our sauerkraut (the long-notorious cachexia of the ill-housed and ill-fed classes having sufficiently indicated the cause of the malady), we suppress the morbid symptoms by sarsaparilla, iodide of potassium, or patent "medicines": only reliable liver-pills and infallible blood-purifiers—in other words, we believe that the cure of a common disease depends upon the accidental or providentially ordained discovery of some mysterious compound. The bottom error is the same as in the king's-evil delusion, and can be easily traced to the radical fallacy of our speculative dogmas; we still regard sin and disease as something normal, aboriginal, and unavoidable, and expect salvation from mysterious, extra-natural remedies, while the truth of the very contrary is becoming more and more evident, namely, that all evil, including moral and physical unsoundness, is due, and generally traceable, to wholly abnormal causes, and (those causes being removed) recovery the effect of the self-acting and self-regulating laws of Nature. The removal of the cause is a remedy which the sufferers from almost any disease might prescribe for themselves, and here especially: fresh air and abstinence from indigestible food, particularly pickles and fat meat. Pork is not the only unwholesome kind of animal food, for Jews are not exempt from scrofula, and were formerly subject to a still worse skin-disease; and, if we had not forgotten the art of interpreting the language of our instincts, we would not overlook the significancy of the circumstance that ninety-nine per cent. of all young children detest every kind of fat meat except in the form of taste-deceiving ragouts. Farmer-boys, who have to share the out-door labors of their parents, can eat with *comparative* impunity many things which only the hardiest of their city comrades can digest: pork, greasy and pickled cabbages, fritters, and salt beef. Even young Hottentots could not eat such stuff without being sooner or later the worse for it, whenever the counteracting hardships of a savage life alternate with a period of physical inactivity. But children afflicted with cachectic symptoms should at once be restricted to a wholly vegetable and non-stimulating diet—farinaceous preparations, boiled legumina, and, if possible, ripe, sweet fruit.

The summer diet of a scrofulous child can not be too *frugal*, in the ancient sense of the word, and, where a supply of ripe tree-fruits can be easily obtained, I should think it the best plan to dispense altogether with made dishes—for a while, even with farinaceous dishes. Parents who have no hesitation in cramming their children with salt pork, beer, and sauerkraut, would shudder at the idea of feeding them on fruit alone, yet the happiest of all visitors to the southern Rhineland are probably the patients of a Swabian *Trauben-Kur*, where dyspeptics, etc., are fed almost exclusively—often for days together quite exclusively—on ripe, sweet grapes. Combined with plenty of exercise

in the bracing air of a highland region, the efficacy of the grape-cure surpasses all the miracles of the king's touch. It will cure children, "too scrofulous to look out of their eyes," cheaper and quicker than any nostrums, and has the still greater advantage of eliminating instead of suppressing the virus.

Those who deny the pharmaceutic efficacy of the homœopathic sugar-pellets can not deny that, in this case, homœopathy has proved the possibility of curing diseases without any drugs at all—merely by a change of diet and regimen. Frugality, abstinence, bathing, ventilation, cold water, and exercise in the open air, have already superseded half the *materia* of the old medical dogmatists, and personal experience has convinced me that the following diseases of children are amenable to a strictly hygienic treatment.

ANCIENT COPPER-MINES OF ISLE ROYALE.

By Professor N. H. WINCHELL.

THESE *mines* are rude, irregularly disposed, shallow pits in the general surface, which, on being cleared of rubbish, are found rarely to exceed the depth of ten feet, but in some instances reach the depth of twenty. They seem to have been located by the accidental outcropping of native copper, over large areas the rock being entirely bare. In other cases, the mining seems to have been systematically prosecuted along the strike of a known copper-bearing belt of rock. In this case it is a rock of marked lithological characters, being of a red color, and, when once its trend was established by a series of pits, it was followed under the drift-materials, that were thrown off into heaps, in which are found, mingled with charred wood and other relics, a great many stone hammers. In one instance, a cross-drift ran under a rude archway from one red belt to another, through a thin partition of darker rock; but, in general, no planning for easy excavation or skillful and prolonged effort in the operations of the miners can be discovered. So far as can be ascertained, they resorted to the very simplest and most laborious methods of excavation in the rock, using their stone hammers, wielded in the hands alone, sometimes aided perhaps by the application of heat, and by repeated blows battered and broke away the rock surrounding the copper masses. When once a mass was detached or sufficiently uncovered, it was parted into smaller pieces by the same means. Some of the masses found, being too large for removal from the pits, show the marks of long-continued pounding, and about them in the pits are a great many small, thin chips of metallic copper, of irregular shapes, with concavo-convex surfaces, exactly such as would be produced by battering a small nugget of

copper to a thin layer by pounding it continuously on the same side. The finding of these thin chips of copper is the first indication to the present miners of the proximity of a large mass. In the summer of 1874 the first of these large masses was discovered. It was sixteen and one half feet below the surface, and under it were poles, as if it had been entirely detached, but it had not been much displaced. This mass was exhibited publicly in the yard of the court-house at Detroit, and was also on exhibition at the Centennial Exposition in 1876. It was subsequently fused and sold as commercial copper. It weighed 5,720 pounds, and has been described by Mr. Henry Gillman, in the annual volume of the American Association for the Advancement of Science for 1875. In the summer of 1879 two other large masses that had been wrought by the ancients were found at the Minong Mine, which is at the head of McCargoe's Cove. One had a weight of 3,317 pounds, and the other 4,175 pounds, the latter being about nine feet long. The largest mass yet found at that place was taken out the previous summer, weighing six tons, but the ancients had not discovered it, though one of their drifts ran within two feet of it. The large masses discovered by the ancients show the labor that has been spent on them in their hammer-marked and pitted surfaces. They seem to have been beaten up into ridges and points, by hammering alone, for the easier removal of parts. One of those found in 1879 was not detached from the inclosing rock, though it was wholly uncovered and undermined. A restoration of its appearance, as represented by Captain William Jacka, is seen in Fig. 1.

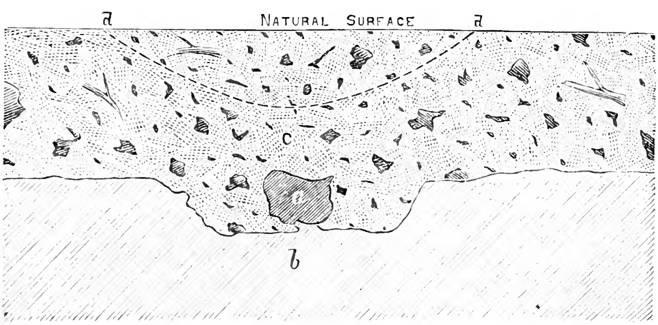


Fig. 1.—*a*, mass of copper; *b*, the inclosing rock; *c*, layer of drift excavated, twelve feet thick; *d d*, line showing surface of the ancient pit before reëxcavation.

Various articles have been found in these old pits or in their neighborhood. Several copper implements, such as a gad, a chisel, knives, and arrow-heads, have been discovered, both on Isle Royale and in the vicinity of similar old mines on the south shore of Lake Superior. Mr. Gillman reports that a large part of a "wooden bowl," originally about three feet in diameter, which had probably been used for boiling water, was taken from one of these pits. The timber found in some

of these excavations bore the marks of an axe, the bit of which must have been about two inches in width. Fragments of charcoal and partially consumed sticks abound. The bark of the white birch is still preserved, though the interior woody portion is wholly rotted. At McCargoe's Cove, Captain William Jacka discovered a wooden shovel or paddle, which showed by its worn and battered side that it had been used in moving dirt. The blade was four and three quarters inches wide, and about twelve inches long. The handle had been broken, but still showed the length of about a foot. It was all perfectly wrought and smooth, and very true in form. A rounded ridge on the upper and lower sides of the blade extended along its middle, tapering off along the same sides of the shaft or handle upward. It was wet and swollen when found, but, on drying, it shrank to a width of three fourths of an inch, and curled out of shape. A restoration of this ancient paddle or shovel is seen in Fig. 2, as drawn under the direc-

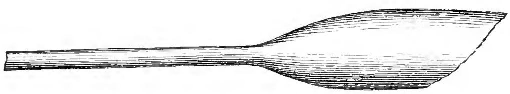


Fig. 2.—Ancient Paddle, used by the Miners on Isle Royale for moving Dirt.

tion of Captain William Jacka, and a cross-section of the blade in Fig. 3 : *a* represents the upper side of the blade, and the ridge, evidently designed to strengthen the instrument, extends to within an inch or two of the end, and gradually and smoothly sinks to the level of the surface. This shovel was found within a few feet of one of the large masses of copper, in the summer of 1879.

Dr. G. K. Gailey also discovered a piece of string, about a foot long, made of some raw-hide, supposed to be of the caribou, tied in the mid-

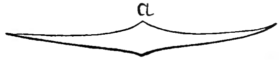


Fig. 3.—Transverse Section of the Blade of Ancient Miner's Tool, from Isle Royale.

dle by "a square knot and a half-hitch." This lay under one corner of the copper mass found in May last (1879), and seemed to break on being pulled out, but the remainder could not be secured. When examined, this string seemed to possess the fiber and much of the strength of dried raw-hide, a circumstance that will not allow the assignment of a very great antiquity to the date of the last mining. Caribou were on the island till a few years ago, and are now common on the shore directly north of the island.

In regard to the main implements of the mines, the stone hammers, they seem not to have been made for the purpose for which they were used. Great numbers of them are found in moving the dirt which the miners handled. They are of various sizes and forms, but generally

about five inches in diameter, though some are eight and even ten inches, and of a rounded oval outline. They were certainly gathered as pebbles along the shore of the lake, north from the island, where there are still others of the same shapes and sizes, and of the same varieties of

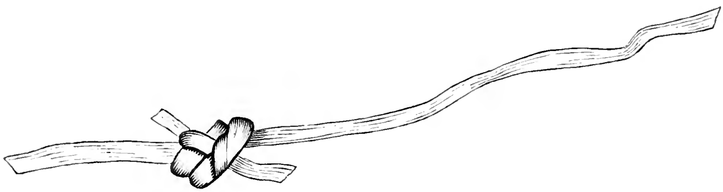


Fig. 4.—Raw-hide String and Knot of the Isle Royale Ancient Miners.

rock, formed on the beach by the action of the waves. The great profusion in which they are scattered among the *débris* of the pits would itself indicate the ease with which they were obtained. They are not grooved for the reception of a withe, like those found on the south shore, near Ontonagon, but they were apparently used for the most part by simply swinging them in the hand, or probably in both hands clasped, thus by repeated blows breaking away the surrounding rock or hammering the desired metal into such shapes as to facilitate its separation in smaller pieces. The rock of which they are composed does not occur as pebbles on Isle Royale, and indeed it is doubtful if it exists at all on the island. It forms the coast of the mainland for several miles opposite the island. It is an igneous rock, usually a diabase, as shown in thin sections under the microscope, consisting essentially of a triclinic feldspar and augite, with magnetite. Sometimes the grains are coarser, and the rock would more properly be styled a dolerite or a gabbro. They belong to the formation designated by Sir William Logan *The Lower Volcanic Group*, but since styled *Animikie Group*, by Professor T. S. Hunt.* Occasionally, however, the workmen seem to have gathered rounded stones of other varieties of rock, though nothing equaling the firmness of the above, and so fit for the purpose of a rude hammer in simple mining, can be selected among all the rocks of the region. One or two, of a granite containing red orthoclase, were seen at the mine, and a few of other granites are reported to have been found. These other varieties are also seen mingled sparsely with the diabase stones along the Canadian shore, and are referable to the drift forces which transported them from farther north and east in Canadian territory.

Although these hammers, as a rule, are not withed, it is still true that occasionally one is found that is withed—i. e., grooved for the reception of a withe handle. One seen at the time of this visit was owned by Dr. Gailey, and was not well wrought. The groove was evidently

* *Vide* "Trap Dikes and Azoic Rocks of Southeastern Pennsylvania," "Second Geological Survey of Pennsylvania," pp. 68, 240.

made by an unskilled hand, and was unfinished. This allies these miners with those of the south shore of the lake. The absence of these hard, rounded stones on the shores of the south side of Lake Superior,* owing to the strike of the formation producing them across the interior of the States of Michigan and Wisconsin, made it necessary for the miners on that side to manufacture their hammers, which they did with greater perfection and symmetry than are seen in the beach-wrought hammers of the Isle Royale miners; and they almost invariably grooved them for a withe. Those found on Isle Royale are generally broken with use on one end or on both, a fact which probably caused their abandonment. Fig. 5 shows the imperfectly grooved

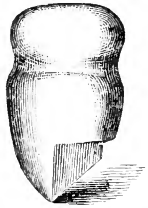


Fig. 5.—Imperfectly withed Hammer, from the Ancient Mines of Isle Royale.

hammer belonging to Dr. Gailey. Fig. 6 shows the outline and irregularity of three others, also found at the Minong mine. These are a fair average for form, of the most of those found. They are also evidently such as would result from the constant attrition of angular fragments on the beach, and show no evidence of designed shaping.

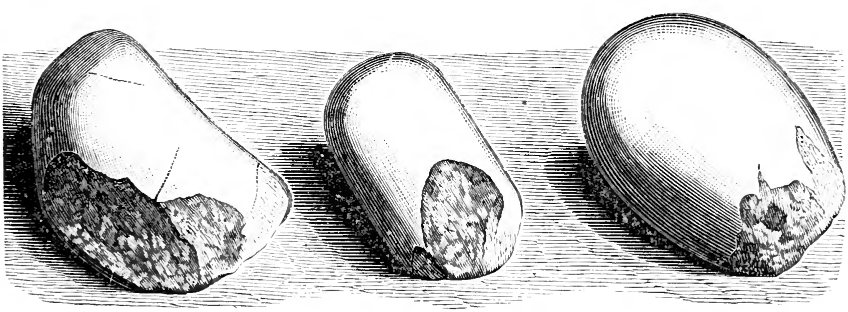


Fig. 6.—Stone Hammers from the Ancient Mines of Isle Royale.

Their battered and even fractured extremities are the only sign of the agency of man in giving them shape.

If we inquire now who were the men, and when did they live, who did this work, we enter on a very interesting question, but one on which we are not in total darkness. A single observation at the pits at once places them *later than the last glacial epoch.* The dirt that

* Ship-loads of these stones are transported from the north shore of Lake Superior for paving streets in Chicago and other cities.

they moved lies on the drift-clay. This is shown by the subjoined diagrammatic sketch taken on the spot (Fig. 7). It is also shown by the fact that some of the pits are but a few feet above the present lake-level (about thirty feet); since during the period of the drift, and particularly toward its close, the interior lakes and rivers of the North American Continent were much higher than they are now.

It has been agreed for some years, by American archæologists, that

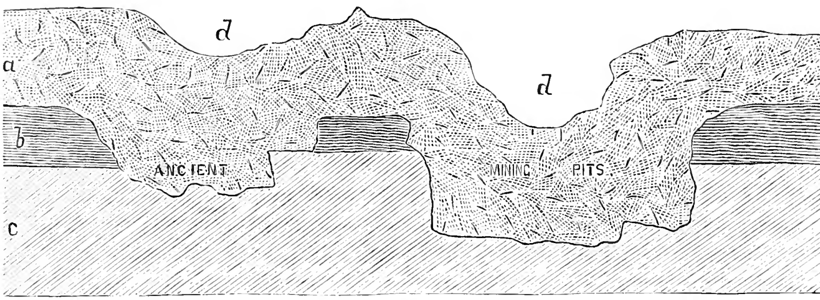


Fig. 7.—Explanation.

a, chips and moved earth in which the stone hammers are found; *b*, the modified drift-clay; *c*, the cupriferous rock; *d d*, depressions in the surface indicating the location of the ancient pits, sometimes refilled by the old miners.

the ancient miners of Lake Superior were identical with the mysterious race known as the mound-builders. The evidence of this, first partially elucidated by Messrs. Squier and Davis, has multiplied by subsequent observations, so that there is now a concurrent series of facts pointing to that conclusion. It consists largely in the discovery of many copper implements in the mounds that have been opened. These implements sometimes contain small nuggets of metallic silver closely welded to the copper. At no other place in the United States are copper and silver found thus naturally combined. They must have been pounded into shape, since the melting of the copper for casting would certainly have produced an alloy in which the appearance of the silver would be entirely lost. This, taken in connection with the well-established mining methods of the Isle Royale miners, undeniably identifies them with the mound-builders.

If we inquire further what relation the mound-builder bore to the aborigines found here by Columbus, we shall be compelled to admit from the evidence that *the aborigines themselves were the mound-builders and the ancient miners.* As this conclusion is at variance with the generally accepted opinion, it will be necessary to consider some of the characteristics of the mound-builders, as stated by the highest authorities, and to compare them with the known peculiar habits and customs of the Indians:

1. Squier and Davis state that "there probably existed among the mound-builders a state of society something like that which prevailed among the Indians; each tribe had its separate seat, maintaining, with

its own independence, an almost constant warfare against its neighbors" ("Smithsonian Contributions," vol. i, p. 44).

2. The mound-builders occupied the entire country from Lake Superior, at least,* on the north, to the Gulf of Mexico on the south, and from the Alleghanies, at least, on the east, to the Sierras on the west. This is demonstrated not so much by the distribution of the mounds—though they are said by Lewis and Clark to occur on the upper waters of the Missouri, and, by Mr. A. Barrandt, in the valley of the Yellowstone—as by the existence of copper implements from Lake Superior in the same mounds with mica from the Alleghanies, pearls from the Gulf shores and from the Carolinas, and sharks' teeth from the cretaceous beds of the South and West.

3. They were an agricultural people, of generally homogeneous customs, habits, religion, and government, each tribe carrying on a trade with surrounding tribes, and some of them with distant tribes.

4. They worked copper in a cold state, having no knowledge of iron, nor of the methods of smelting any of the ores of the metals by the aid of fire.

5. They built extensive earthworks and mounds, both for purposes of warfare and for sepulture.

6. They exhibited very frequently a remarkable flattening of the shin-bone (*platycnemism*).

7. They made a coarse kind of cloth, by twisting and weaving the fibers and bast of various plants.

8. They made pottery of clay, which they hardened by burning, and rudely ornamented with figures of animals, or by simpler lining.

9. They wrought stone, making axes, arrow and spear heads, knives, wedges, pestles, discoidal stones, tubes, pipes, beads; and they had a high regard for mirrors of mica.

10. They made rude sculptures, in stone and burned clay, of animals and of the human face.

11. They had no knowledge of writing by the use of an alphabet, nor hieroglyphics; but sometimes resorted to pictures to convey information.

12. They employed shells, pearls, sharks' teeth, obsidian, copper, silver, steatite, black and mottled slate, mica, coralline limestone, the bones of some animals, and some other minerals, especially galena and hematite, for making articles of personal adornment.

13. Besides rude sculptures of most of the present animals of the larger types, the elephant (or mastodon) was also known to them, as evinced by the "elephant-mound" in western Wisconsin, by the dis-

* Along the boundary-line between Minnesota and the Canadian territory are occasional mounds. One very large one is on the Canadian side of Rainy Lake River, at the Big Sioux Rapids (N. Butler). They are found near Grand Marais, on the north shore of Lake Superior.

coveries of Dr. Koch in Missouri, and by the "elephant-pipe" lately brought to light in Louisa County, Iowa.*

Some of these characteristics it is only necessary to name, to enable any one to recognize also their belonging to the red-men who were here when Columbus discovered America, and who probably are identical with the *Skrellings* seen by the Norse adventurer, Thorwald Ericson, in 1002, described as having sallow-colored, ill-looking faces, ugly heads of hair, large eyes, and broad cheeks, coming to his ship in canoes for purposes of trade, but becoming hostile and treacherous. The various tribes into which the red-men were, and still are, divided, extended over the whole territory that is known to have been occupied by the mound-builders.

That they were an agricultural people, although given to warlike expeditions, and to long journeys for the purpose of trade and for rice-gathering and hunting, is also abundantly attested by the journals of the earliest explorers. Of these it is only necessary to refer to those of Hudson and Juet in the Half-Moon, who mention in several places the existence of extensive cultivated fields along the banks of the Hudson, and to the historians of De Soto's expedition, who speak frequently of Indian villages containing from fifty to six hundred dwellings, substantially constructed of wood, in which must have dwelt upward of two thousand persons. They frequently mention, also, extensive fields of corn, beans, pumpkins, and other vegetables. In one instance De Soto's army traveled two leagues through fields of corn, and sometimes large quantities of corn and of meal were obtained from the houses (*vide* Irving's "Conquest of Florida").

The fact that the aborigines worked stone, using stone axes, arrow-heads, disks, wedges, hammers, pestles, and scrapers, is authenticated not only by the testimony of early writers, but also by the continuance of the same custom nearly if not quite up to the present time among some of the most inaccessible tribes of North America, though they have almost wholly ceased to be used, in consequence of the metallic implements furnished them by the whites.

The manner of making pottery among the Mandan Indians is described in detail by Catlin, who states that "earthen dishes are made by the Mandan women in great quantities, and modeled in a thousand forms and tastes," and that they are nearly equal in hardness to our own manufactured pottery, though they knew not the art of glazing. Fragments of pottery, evidently made by these Indians, are found about Bismarck, in Dakota, and on the Heart River, and in various parts of northern Minnesota, where it was doubtless made by the Chippewas; and they greatly resemble the pottery taken from the mounds, being unglazed, gray, slightly baked or unbaked, and somewhat ornamented by lines and figures.

The articles of cloth that have been found in the mounds are made

* John T. Short, "The North Americans of Antiquity," p. 530.

of the bast-fibers of certain plants, and have been preserved by "the antiseptic action of the salts of copper," the cloth having been wrapped about copper axes and nuggets prior to being placed in the mounds.* It appears to be "a kind of hemp, possibly the *Apocynum cannabinum*, formerly used by the Aztecs," or perhaps, as suggested by Colonel D. A. Robertson, of St. Paul, the fibers of *Urtica gracilis*. Cloth of equal fineness is still made by several of the Indian tribes, particularly by the Navajoes of New Mexico; and nearly all of the tribes are known to have had mats and even carpets, woven of various sedges or of bast-fibers. They are still made by the Chippewa Indians in northern Minnesota.

The sculptured objects taken from the mounds, even those of the human face, are generally cut in some very soft stone, or are made of clay. They are equaled in skill and design by the sculptured pipes

FIG. 8.—From photograph of an image found in the valley of Root River, near Lanesboro, Minnesota, April, 1880. The mound from which it was taken also contained stone arrow-heads, one copper ditto, clay-burned pipes, among the remains of a large number of human skeletons. The image was evidently made of clay burned to be very hard. The back or reverse side is nearly flat. The nose is partly broken off.

and hatchets the Indians have been known to make ever since the Columbian discovery, and particularly by those made of the famous red pipestone or Catlinite † of Minnesota. As illustrative of the sculpture of the mound-builders, Fig. 8 is here presented. This is from a photograph of a representation of the human face taken from a mound

* R. J. Farquharson, "Recent Explorations of Mounds near Davenport, Iowa," "Proceedings of the American Association for the Advancement of Science," vol. xxiv, p. 305.

† Mr. Farquharson ("American Association for the Advancement of Science," vol. xxiv, p. 306) speaks of a green variety of *Catlinite*, which, on the contrary, is always red. Other American archæologists have in the same way spoken of *Catlinite* (?) pipes found in the mounds, but which by the descriptions given are precluded from being *Catlinite*. The Chippewa Indians of Minnesota make pipes of a greenish argillitic slate, obtained near

lately opened at Lanesboro, in Fillmore County, Minnesota. For this I am indebted to the kindness of Mr. H. G. Day, who states that the image was found in the same mound with stone arrow-heads, one copper arrow-head, clay-burned pipes, and the remains of a large number of human skeletons. This piece of burned clay, about three inches in height, represents the human face, and is certainly not evidence of greater skill than the Mandan pottery made by the women of that tribe, but shows that the burning of clay was a practice common to both peoples.

There was a time, recently, when the flattening of the shin-bone was claimed to be a striking peculiarity of the mound-builders. This view was very fully set forth by Mr. Henry Gillman, in his papers on the contents of several Michigan mounds, particularly those on the Rouge and Detroit Rivers, explored by him in 1869 and 1870 ("Smithsonian Report," 1873). This view has also been advocated by Dr. A. E. Johnson, before the Minnesota Academy of Sciences, in a description of bones taken from a mound at Palmer Lake, near Minneapolis. If this distinction could be fully established, it would be one of the most valuable and one of the most remarkable ethnological discoveries of American scientists, and would form a basis for future investigations that might fully establish the distinctness of the mound-builder among the dynasties of North America. But, according to Mr. Gillman's own observations, made at a later date, this peculiarity is not uniform nor constant in the tibiæ taken from the Michigan mounds, and in some mounds it is wanting. The same is true of the perforation of the humerus, which has also been regarded as peculiar to the mound-builder. Of six humeri taken by the writer from mounds at Big Stone Lake, Minnesota, but one was perforated. Both these osteological variations are found occasionally in the present Indian, and the former is very common in the negro and in the ape. Dr. Jeffries Wyman informs us, according to Professor J. D. Dana, that the platycnemic tibia is a common fact among the American Indians, as well as in the prehistoric remains of Europe. More lately a platycnemic tibia from the Lanesboro mound was submitted to Professor Leidy, of Philadelphia, who, in reply to a question as to its significance, stated that it was now regarded as of no special significance, but was a common occurrence in the early races.*

We come now to consider the most interesting as well as the most difficult points in the genetic relationship of the Indian and the mound-builder. These are the existence of the mounds, the mining

the international boundary, but the Sioux use the *Catlinite* of the celebrated pipestone region, in southwestern Minnesota. By trade the *Catlinite* sometimes finds its way into the northern part of the State, and is employed as inlaid ornaments in the dark slate, in the same manner as lead is used for a similar purpose.

* For a knowledge of this correspondence I am indebted to Rev. E. D. Neill, of the Minnesota Historical Society.

of copper, and the use of copper implements. The Indian, it is said, knows nothing of the mound—that is, nothing of its origin. He also avers, at the present time, that he knows nothing about the copper knives, axes, and arrow-points that are shown him. This fact, taken with a sentiment that has exalted the builders of the mounds to a stage of civilization far in advance of that evinced by the commonalty of the savage races of North America as they exist in the eighteenth and nineteenth centuries, has erected a barrier between the Indian and the mound-builder, which, though wholly imaginary when subjected to close analysis, is so great that they have been regarded either as misinformed, or rash, who have ventured to question its validity. Messrs. Squier and Davis, who first systematically explored and described the remarkable mounds of the Ohio Valley, were led to regard the mound-builders as a race wholly distinct from the Indian ("Smithsonian Contributions to Knowledge," vol. i, 1848), and this view is also maintained by the beautiful and able work of Mr. John T. Short ("The North Americans of Antiquity," 1880). Mr. Squier, however, in his work on the "Aboriginal Monuments of the State of New York" ("Smithsonian Contributions," vol. ii), in 1849, mentions many points of resemblance between the mound-builder and the Indian, though he does not specifically state that the Ohio Valley earthworks are probably of Indian origin, while he does conclude that the mounds and earthworks of western New York, as well as their contents, are the product of the Iroquois. Mr. Lapham, in vol. vii of the "Smithsonian Contributions," unhesitatingly ascribes the mounds and the copper-mining to the Indians, but his opinion has been generally ignored. Colonel J. W. Foster, in "Prehistoric Races of the United States," makes light of Mr. Lapham's views.

Upon consulting a number of works in the library of the Minnesota Historical Society that bear on this subject, it is found that there are a great many more references to the use of copper by the Indians, and to their knowledge of its origin, than has generally been supposed. They are too numerous and circumstantial, and are spread over too wide a stretch of time, to be supposed to be exceptional.

Following are a few quotations from early journals and histories that seem to demonstrate not only that the Indians used and mined native copper, but that they also erected mounds of earth, or of stones, in commemoration of their honored dead, and for sepulture. The Indian is a dull utilitarian. He is but little given to sentiment. As he knows nothing of the future, so he remembers little of the past. Hope and history are alike feeble in his mental garniture. His traditions are worthless, and "his chronology of moons and cycles is an incoherent and contradictory jumble."* If he says he knows nothing of these relics, his testimony can apply only to himself personally, for his ancestors, on the most undeniable evidence, did know all about them.

* Short, "The North Americans of Antiquity," p. 22.

In regard to the use of copper, and the mining of it, by the American aborigines, may be made the following quotations and references:

In the "Collections of the New York Historical Society," second series, vol. i, is given a translation of the Italian account of the voyage of John de Verazzano along the coast of North America, from Carolina to Newfoundland, A. D. 1524. When about at Narragansett Bay and Harbor he makes these notes: "We saw upon them [the aborigines] several pieces of wrought copper, which is more esteemed by them than gold, as this is not valued on account of its color, but is considered by them as the most ordinary of the metals, yellow being the color especially disliked by them; azure and red are those in highest esteem by them." Further on he says of another tribe: "In this region we found nothing extraordinary except vast forests and some metalliferous hills, as we infer, from seeing that many of the people wore copper ear-rings."

Henry Hudson's ascent of the river that bears his name is given in the same volume, in the form of a journal kept by Robert Juet, mate. Speaking of the natives, on page 323, Juet says: "They had red copper tobacco-pipes, and other things of copper they did wear about their necks"; also, "They have great tobacco-pipes of yellow copper"; also, on page 300, Hudson himself says, "The people had copper tobacco-pipes, from which I inferred that copper might naturally exist there."

Raleigh observed copper ornaments among the Indians on the coast of the Carolinas; Granville, in his voyage in 1580, observed copper in the hands of the natives of Virginia, and made an effort to reach the place where they said it was obtained. After a toilsome journey into the interior, of some days' duration, the attempt was abandoned. Heriot's "Voyage," in Pinkerton, vol. xii, p. 594, gives an account of copper found "in two towns one hundred and fifty miles from the main, in the form of divers small copper plates, that are made, we are told by the inhabitants, by people who dwell farther in the country, where they say are mountains and rivers which yield white grains of metal which are deemed to be silver. For confirmation whereof, at the time of our first arrival in the country, I saw two small pieces of silver, grossly beaten, about the weight of a tester [an old coin about the weight of a dime], hanging in the ears of a Wiroance. The aforesaid copper we found to contain silver." McKenzie found copper in use among some of the extreme northern tribes, on the borders of the Arctic Sea, according to his "Second Voyage," page 333, as quoted by Squier.* "They point their arrows and spears with it, and work it up into personal ornaments, such as collars, ear-rings, and bracelets, which they wear on their wrists, arms, and legs. They have it in great abundance, and hold it in high estimation." Alexander Henry,

* "Smithsonian Contributions," vol. ii, p. 117. Bancroft ("Races of the Pacific Slope") mentions the mining of copper on Coppermine River, by existing tribes.

in his "Travels," page 195, states that the Indians obtained copper at Lake Superior, "which they made into bracelets, spoons, etc." De Soto found copper hatchets in possession of some of the tribes along the coast of the Gulf of Mexico, which they stated they obtained from a province called Chisca, far to the north. Claude Allouez, in 1666, visited Lake Superior, and states that "it happens frequently that pieces of native copper are found, weighing from ten to twenty pounds. I have seen several such pieces in the hands of savages; and, since they are very superstitious, they esteem them as divinities, or as presents given to them to promote their happiness, by the gods who dwell beneath the water. For this reason they preserve these pieces of copper wrapped up with their most precious articles. In some families they have been kept for more than fifty years; in others they have descended from time out of mind, being cherished as domestic gods. For some time there was seen near the shore a large rock of copper, with its top rising above the water, which gave an opportunity for those passing by to cut pieces from it; but when I passed that vicinity it had disappeared. I believe that the gales, which are frequent, like those of the sea, had covered it with sand. Our savages tried to persuade me that it was a divinity who had disappeared, but for what cause they were unwilling to tell" (Foster and Whitney's "Report on Lake Superior," Part I, page 7). Dablon, in his "Relation" for 1669–'70, states that "the savages did not agree as to the source of the copper. Some say that it is where the river [Ontonagon] begins, others that it is close to the lake, in the clay, and others at the forks and along the eastern branch of the river." Again, Dablon gives an account of its being reputed to occur on an island about forty or fifty leagues from the *Saut* toward the north shore, opposite a place called Missippicoatong (Michipicoten?). The savages related that the island was a floating island, sometimes near and at other times far off. These statements, with other particulars, make it very probable that the Indians of Lake Superior were familiar with the localities prior to their acquaintance with the French, and that the place here described can be no other than the even then celebrated mines of Isle Royal.

Jacques Cartier in 1535 spent the winter at or near Quebec, and learned several facts concerning copper that was in possession of the Indians, which he has given in his "Brief Recital." They made an effort to explain to him where the copper came from. They gave Cartier to understand that there were large quantities where they obtained it, situated on a bank of a river near a lake. One of the chiefs drew from a sack a piece of copper a foot long and gave to Champlain. "This was quite pure and very handsome." He said they had "gathered it in lumps, and having melted it spread it out in sheets, smoothing it with stones." * The Indians at Montreal and

* Champlain's "Voyage du Sieur de Champlain," Paris, 1613, p. 246, as quoted by Slafter.

Quebec in 1535 were familiar with the fact that *Saguenay* was a copper-bearing region. John Gilmary Shea, LL. D., says (Shea's "Charlevoix"): "The *Saguenay* of the St. Lawrence Indians was evidently the Lake Superior region, and possibly the ports accessible by the Mississippi. The river *Saguenay* was not so called from being in but from leading to *Saguenay*." Thus, at a distance of from eight hundred to one thousand miles from its origin, Cartier in 1535, and Champlain in 1610, encountered Indians who informed them of the manner of mining, and of manufacturing copper implements, Champlain stating that the copper was melted.

It is not presumed that this is a complete list of historic references to the use of copper and copper mining by the Indians, but it is amply sufficient to show that it is not necessary to invoke a strange race, prior to the Indian, to account for all the copper implements and the nuggets of copper that have been found in the mounds, as well as for those found on the surface of the ground throughout the Northwest.

The term *mound-builders* is distinctively applied to the race that constructed the remarkable earthworks of the valley of the Ohio, and of the interior of the United States in general, but it is true that in nearly all parts of the world the practice of mound-building has prevailed, sometimes among nations that come within historical epochs. Mounds are found among the Celts and the Scythians, in the Sandwich Islands and in New Zealand, in Japan and India, and throughout the central parts of the Eastern Continent, as well as in both Americas, from the country of the Esquimaux to Chili and Fuegia. The earliest of human records refer distinctly to this method of honoring the dead. The heroic age of Greece, as sung by Homer, abounded with ceremonies and curious details relating to the *tumulus* erected over the bones of the slain hero. The burial of Patroclus, as related in the twenty-third book of the "Iliad," is an illustration of the practice of mound-building by the ancient Greeks:

"The sacred relics to the tent they bore,
The urn a veil of linen covered o'er.
That done, they bid the sepulchre aspire,
And cast the deep foundations round the pyre;
High in the midst they heap the swelling bed
Of rising earth, memorial of the dead."

At the burial of Hector, the Trojans erect a pile of large stones over the urn containing his remains, and upon that pile up the tumulus. When Æneas buried the pilot of his fleet, Misenus, he

"... piously heaped a mighty mound sepulchral."

Artachæas, superintendent of the canal at Athos, was honored by Xerxes with a memorial mound which still remains, in remembrance of the skill of that engineer, and an evidence of the custom of the

Persians. The Scythian kings are entombed in *tumuli* along the banks of the Dnieper. Orestes, bewailing his father, Agamemnon, says:

> "If but some Lycian spear 'neath Ilium's walls
> Had lowly laid thee,
> A mighty name in the Atridan halls
> Thou wouldst have made thee.
> Then hadst thou pitched thy fortunes like a star,
> To son and daughter shining from afar,
> Beyond the wide-waved sea the *high-heaped mound*
> Had told for ever
> Thy feats of battle, and with glory crowned
> Thy high endeavor."

In Asia Minor the tomb of Alyattes, the Lydian king, has a circumference of nearly a mile, requiring ten minutes to ride round its base. In the same neighborhood, near the lake Gygæa, are numerous other circular mounds.

The same practice was continued into the later days of Grecian history. Alexander raised a mound over Demaratus, which, Plutarch says, was "eighty cubits high and of vast circumference." The *tumulus* erected on the plain of Marathon, in commemoration of the one hundred and ninety-two Athenians who fell in the battle, is near the sea, and is to be seen by all travelers. It is about one hundred feet in circumference, and about twenty-five feet high. Finally, coming within the scope of modern history, the construction, at the order of the English Government, of a mound of earth on the plains of Waterloo, attests the tenacity of that sentiment of veneration for the dead who die in the service of their country, and the persistence of a practice, which seems to be common to all mankind and to have survived from prehistoric times, of resorting to the mound of earth, as being at once the easiest made and the most enduring monument in memory of the departed.

The practice of mound-building not being distinctive of any race, tribe, or epoch of the human family, it may be considered not at all unlikely that the aboriginal tribes of America, perhaps without exception, had their ceremonies and habits of burial, if not other rites of a sacred character, in one way and another associated with the erection of mounds of earth. Indeed, it would be a remarkable exception if the native Americans did not erect mounds. They possessed the land without molestation prior to the discovery of Columbus. They had the necessary elements of perpetuity and stability, at least so far as these can be predicated of savage tribes. They cultivated the soil and conducted a considerable trade with their neighbors. They exhibited all other characteristics common to mankind in an uncivilized state. The denial of their resort to mound-building, for the same purposes as other tribes in similar circumstances, carries with it the necessity to account for such an anomalous exception.

It is often stated that the Indian, when interrogated concerning the mounds and earthworks of the country, shakes his head in ignorance, affirming that he knows not their origin. This fact is carried further than it should be when it is invoked to prove the non-Indian origin of these mounds. Admitting, with some reservation, that the Indian at present knows nothing of the origin of the mounds, still it may be true that his immediate ancestors were familiar with the facts of their erection. The Indian has been driven from the home where he was born, and where his ancestral traditions and customs have centered and exhibited their unconstrained development, and has been a fugitive for several generations, from the cupidity and the bayonet of the white man. When it is remembered that the erection of a mound, such as are seen all over the Northwest, was not the act of a day, nor of a year, but of many years, and perhaps generations, it is easy enough to understand why the custom has become so nearly extinct. The Indian has become greatly modified by contact with the European. He has gradually been compelled to forsake many customs and abandon arts, which came into competition with the customs and the arts of the stronger race. The semi-nomadic life which he has been compelled to adopt has not been favorable to the erection of mounds, which requires the quiet of permanent and peaceful residence.

We are not, moreover, without testimony to the fact that the present Indian tribes did build mounds. Lewis and Clark mention the custom among the Omahas, saying that "one of their great chiefs was buried on a hill, and a mound twelve feet in diameter and six feet in height erected over him. Bertram states that the Choctaws covered the pyramid of coffins taken from the bone-house with earth, thus raising a conical hill or mound. Tomochichi pointed out to General Oglethorpe a large conical mound near Savannah, in which he said the Yamacraw chief was interred, who had, many years before, entertained a great white man with a red beard, who entered the Savannah River in a large vessel, and in his barge came up to the Yamacraw bluff. Featherstonhaugh, in his "Travels," speaks of the custom among the Osages, referring to a mound built over the body of a chief, called Jean Defoe by the French, who unexpectedly died while his warriors were absent on a hunting expedition. Upon their return they heaped a mound over his remains, enlarging it at intervals for a long period, until it reached its present height. Bradford says* that many of the *tumuli* formed of earth, and occasionally of stones, are of Indian origin. They are generally sepulchral mounds—either the general cemetery of a village or tribe, funeral monuments over the graves of illustrious chiefs, or upon a battle-field, commemorating the event and entombing the fallen, or the result of a custom, prevalent among some of the tribes, of collecting at stated intervals the bones

* "American Antiquities and Researches into the History of the Red Race," 1841, p. 17.

of the dead, and interring them in a common repository. A mound of the latter description was formerly situated on the low grounds of the Rivanna River, in Virginia, opposite the site of an old Indian village (Jefferson's "Notes on Virginia," pp. 100, 103). It was forty feet in diameter and twelve feet in height, of a spheroidal form, and surrounded by a trench, whence the earth employed in its erection had been excavated. The circumstances attending the custom alluded to were, the great number of skeletons, their confused position, their situation in distinct strata, exhibiting different stages of decomposition, and the appearance of bones of infants. A mound of similar character, and constructed in layers or strata at successive periods, existed near the south branch of the Shenandoah, in the same State. A *tumulus* of stones, in New York State, is said to have marked the grave of a distinguished warrior (McCauley's "History of New York," vol. ii, p. 239). "Beck's Gazetteer" (p. 308) states that "a mound of the largest dimensions has been thrown up, within a few years, in Illinois, over the remains of an eminent chief." The Natchez Indians, when expelled from Louisiana in 1728, erected a mound "of considerable size" near Natchitoches, as stated in the documents accompanying the President's message for 1806. C. C. Jones, referring * to plate xl of the "Brevis Narratio," says that "here we have a spirited representation of the ceremonies observed by the Florida Indians upon the occasion of the sepulture of their kings and priests. Located in the vicinity of the village appears a small conical mound, surmounted by the shell drinking-cup of the deceased, and surrounded by a row of arrows stuck in the ground. Gathered in a circle about this sepulchral *tumulus*, the bereaved members of the tribe, upon bended knees, are bewailing the death of him in whose honor this grave-mound had been heaped up." Jones also mentions an instance of a primary burial under a mound erected in honor of the dead, on the coast a few miles below Savannah, in which, along with an earthen pot, several arrow-heads, a stone celt, and bones of a human skeleton, was found in immediate association *a portion of an old-fashioned sword*. This *tumulus*, thus proved to have been erected since the advent of the Europeans, was seven feet high and about twenty feet in diameter at the base. Of the sword, the parts preserved were the oak handle, most of the guard, and about seven inches of the blade. The rest had perished from rust. The Mandans, according to Catlin ("North American Indians," vol. i, p. 90), constructed mounds in commemoration of their dead, and the same is said of the Arickarees by Professor Lewis H. Morgan (twenty-first report of the New York State Cabinet). The mounds at Lanesboro, in the State of Minnesota, are said by the old Winnebago chief Winneshiek † to have been erected by the Sioux, in commemoration

* "Antiquities of the Southern Indians."

† This old chief is still living, near Trempeleau, Wisconsin, and is said to be about one hundred years old.

of a great victory won there over the Winnebagoes many generations ago. The same old chief, when shown a clay pipe taken from the Lanesboro mounds, said it was like those made by the Sioux, and, pointing to an earthen spittoon for illustration, said the Sioux made many like it. In the "Proceedings of the American Association for the Advancement of Science," for 1875, Dr. Sternberg, of the United States Army, critically analyzes the contents of certain mounds near Pensacola, Florida, and concludes that they were built by different but contemporaneous tribes of Indians, one being probably the Natchez. In these mounds were found pottery, red hematite for pigment, flint weapons, and shell ornaments in the shape of beads and perforated disks, in conjunction with *blue-glass beads and fragments of iron.* The latter show that these mounds were still used, or in process of erection, later than the advent of Europeans.

Mr. E. G. Squier, in the second volume of the "Smithsonian Contributions to Knowledge," has described in detail many mounds and earthworks of western and central New York, remarking that they extend down the Susquehanna as far as the valley of the Wyoming, northward into Canada, along the upper tributaries of the Ohio, and westward along the shores of Lakes Erie and Ontario. These mounds and earthworks are said generally to be smaller than those in the Ohio Valley. They were found to contain ornamented pottery, pipes of clay regularly and often fancifully molded, or bearing the forms of animals, stone axes and hammers, stone disks and implements which the author remarks are almost identical in shape and material with some described by him from the mounds of the Ohio Valley, and spear-points and bodkins of bone. In connection with these are described articles of European manufacture, such as cast copper and iron axes, and kettles of copper, iron, and brass. Although Mr. Squier had previously expressed the opinion that the earthworks of western New York were of like nature and origin with those of the Ohio Valley, when confronted with the fact of articles of European manufacture commingled with aboriginal, discovered by his own investigations, he was forced to assign the New York mounds to the Iroquois. It seems not unreasonable to assume that the New York series of mounds will be found undistinguishable from those of northern Ohio and eastern Michigan, which have unquestioningly been regarded as of the same age as those of the Ohio Valley, as well as synchronous with those of Wisconsin, which, while possessing all the essential characters of the Ohio Valley mounds, have been assigned as unhesitatingly to the existing races of Indians by the late J. A. Lapham, of Milwaukee.

It hence seems demonstrable, as well as admitted by some of the best American ethnologists, that the existing Indian races formerly carried on extensively and methodically the practice of mound-building. The mounds of sepulture are often referred to by historians and

travelers. They were built by slow accretions. Not to mention the veneration which impelled the untutored savage to cast a handful of earth on a mound every time that he passed it, in testimony of his remembrance of the departed, it may be well to refer to what has been known as the *feast of the dead.* This is asserted to have been common to many tribes, although conducted with some variation of details. Gathering the bones of the dead from their temporary resting-places, the tribe assembled at a chosen spot, and with solemn ceremonies performed the last rites of sepulture. Sometimes they were placed in coffins separately, and buried within a pit over which was erected a mound of earth, and sometimes they were arranged serially, and simply buried under a mound. More frequently the bones were burned, the cremation being accompanied with lamentation and followed by feasting. The ashes and the unconsumed fragments were then covered with earth. For many generations this *feast of the dead,* which occurred sometimes every eight years, or every ten, or when the accumulated bones made it necessary, was doubtless performed on the same spot ; and in course of time a mound of considerable dimension was the result, which, while containing human bones, or fragments of them, and much evidence of fire in the form of ashes and charcoal, and reddened stones, yet discloses, on exhumation, no perfect skeletons.

As further testimony to the erection of mounds by the present Indians, the statements and opinions of a few who have investigated the subject, or have dwelt long with them, may be referred to.

Mr. Jones, in his review of the "Antiquities of the Southern Indians," remarks : "During the progress of this investigation it will be perceived that mound-building, which seems to have fallen into disuse prior to the dawn of the historic period, was entirely abandoned very shortly after intercourse was established between Europeans and the red-men." Again, in summing up the evidence, Mr. Jones says, in conclusion, "In a word, we do not concur in the opinion, so often expressed, that the mound-builders were a race distinct from and superior in art, government, and religion, to the Southern Indians of the fifteenth and sixteenth centuries." Bradford, in "American Antiquities and Researches," affirms that "from very respectable authority it appears that many tribes still continue to this day to raise a *tumulus* over the grave, the magnitude of which is proportioned to the rank and celebrity of the deceased."

From the foregoing it appears that every known trait of the mound-builder was possessed also by the Indian at the time of the discovery of America. It hence becomes unnecessary to appeal to any other agency than the Indian. It is poor philosophy and poor science that resorts to hypothetical causes when those already known are sufficient to produce the known effects. The Indian is a known adequate cause. The assignment of the mounds to any other dynasty was born

of that common reverence for the past, and for the unexplainable, which not only unconsciously augments the actual, but revolts at the reduction of these works to the level of the existing red-man.

WRITING PHYSIOLOGICALLY CONSIDERED.

By CARL VOGT.

MODERN investigations have shown us that certain parts of the brain, situated in the region of the temples, have a predominant share in the formation of articulate language; or, to express it in a short phrase, that the majority of men speak by means of the third frontal circumvolution of the left cerebral hemisphere. All who have occupied themselves a little with physiology know also that the nervous fibers cross each other in the brain, so that the movements of the left arm are commanded by the right hemisphere, while those of the right arm depend on the left hemisphere. Rushes of blood, extravasations, and apoplexies are unfortunately more frequent on the left side than on the right side of the brain: attacks of the left hemisphere are consequently followed by paralysis of the right limbs, and aphasia, or an impossibility to speak; but injuries to the right hemisphere, while they paralyze the left limbs, generally leave language untouched.

Does this center exist for writing as well as for language? Inasmuch as we are in the habit of writing with the right hand, it is evident that the movements necessary for the action of writing must be paralyzed by an affection of the left hemisphere. But we may learn to write with the left hand. The question, we see, becomes general; it extends to the general movements in writing, and is concentrated at last in a single point: are there facts which force us to admit a particular cerebral center, on which the movements in writing depend? In other words, does the manner in which we write depend upon a physiological necessity—determined by the structure of the brain? All peoples write with the right hand. It is of little importance whether this preponderance of the right is founded on a particular structure, or whether it is in great part the result of education and habit; man, writing with the right hand, writes therefore under the direction of the left cerebral hemisphere.

If this is a general fact, and I know of no exception to it, we may ask how it happens that the arrangement of the letters and the lines is so different among different peoples. The peoples of Eastern Asia, as a rule, arrange their letters from above down, and the lines from right to left; the Shemites and the Europeans put the lines one below another, but the Shemites arrange their letters from right to left, while the Aryans arrange theirs from left to right. The Shemites have centripetal writing, the Aryans have centrifugal writing.

The subordination of these three so different directions of writing to a single physiological principle is possible only in case we can show that there is only one normal direction in writing, and that the deviations from this normal direction are due to powerful causes and influences, which have prevailed over the direction primarily imposed by the structure of the brain.

It is necessary, while we are occupied with this question, to distinguish between the order of the lines and the letters and the formation of the letters themselves. The two things are in a certain degree independent one of the other. The individuality of the writer is manifested in the form, in the proportions of the letters, while the manner in which the lines and the letters are arranged one after the other displays no character of individuality.

A complete analysis of all the external influences that can have acted on the manner of writing is necessary to decide whether there exists only a single order of letters and lines imposed by nature, or whether the diversity which we see to-day is produced solely by external causes.

But the solution of this question, whatever it may be, will not suffice to furnish a detailed analysis of the cerebral functions that are put in action by writing. The formation of a letter by the hand that writes supposes necessarily that, by the movements of the fingers and the hand on one side and the visual impression of the eyes on the other, a conception of the figure produced is formed in the brain, which is retained for a certain time by the memory. The time required for the formation of the conception and the transmission from the brain of the will to produce the action is shortened by frequent exercise till the act comes to appear nearly unconscious. The more frequently a man writes, the more also will the figurative images produced by writing be fixed in his brain. But as his impressions and images are transmitted to his brain only by the muscular sensation of the single right hand—with the coöperation of the eyes, indeed—we have a right to expect that experiments and observations made on certain cerebral parts of paralytic patients will cast some light on the manner in which these figurative and largely unilateral images of the writing are formed and preserved in the brain.

For the present, we will occupy ourselves with the question, How did the ancients, how do the moderns, write? What were and what are the materials that they employ? Can we discover any connection between purely external causes and the manner of arrangement of the letters and lines?

So far as we know, representation by images has been the point of departure for all writing. Three primitive methods of writing were developed in the Eastern Hemisphere from the initial imagery: that of the East of Asia, or the Chino-Japanese method; that of the West of Asia, or the cuneiform; and the Egyptian, or hieroglyphic writing.

From the last were developed, step by step, the hieratic writing and the demotic alphabet, or current hand. The arrangement of the hieroglyphics was determined by no rule, but was dependent only on the form and size of the space in which the inscription was to be written.

It is absolutely indifferent to us whether we know what part the Egyptian demotic or the cuneiform writing has taken in the formation of existing alphabets. It is enough to know that we have three entirely independent forms of writing: the Chino-Japanese, which arranges the letters from the top down, and the lines from right to left, or centripetally; the Shemitic, which arranges the letters centripetally from right to left, and the lines one below the other; and what we may call the Aryan, which arranges the lines in the same manner, while it places the letters centrifugally, from left to right.

The last two styles may have been formed through a mingling of the demotic and cuneiform methods. Their common point of departure is in any case to be found in the hieroglyphics, and it is doubtless to this origin that we should attribute the absolute want of a fixed rule in the order of the letters and the lines in the most ancient specimens. Mr. J. J. Leslie, in his lectures on the origin and destination of man, speaks especially of the complete indifference of the ancient writers in regard to the placing of their letters. Many of the old Greek inscriptions were written alternately from right to left and from left to right, turning the direction as one turns a plow in the field, and this style was called "boustrophedon" (*turning like oxen*). The Egyptians often wrote in the same manner, and M. Stern says that the hieroglyphic inscriptions might, according to the nature of the characters used, run from the top down, from left to right, or from right to left—the latter direction, as in Shemitic writing, being the most common.

We conclude, generally, from these facts, that the arrangement of the images which were transformed successively into phonetic signs and letters had no rule as long as those images, signs, or letters, were engraved or painted on an immovable material, as stones, columns, or architectural monuments. The arrangement was governed by the character and shape of the material; it was horizontal on a cornice, vertical on a post, spiral on a column, according to the convenience or fancy of the writer. There is no place here for a fixed rule based on physiological necessity.

It was only when the man ceased to move before an immovable material, but when, on the other hand, the material (plates, tablets, paper, etc.) became movable before the man having a fixed position, that the normal directions as we now observe and distinguish them were established.

Do physiological reasons exist for the present methods of writing? Let us examine, with regard to this point, all the exterior conditions under which writing is done, beginning with the Chino-Japanese system. The people who employ this system do not write; they paint,

using a brush which is manipulated slowly and makes a thick stroke, and follow the order of arrangement of their mural pictures. Their temples are made of wood, and it is the posts that are ornamented, naturally from the top down. This direction is also most convenient in all painting, since it corresponds with the natural movements of the joints of the fingers.

The Shemitic peoples—the Bedouins of the desert, Arabs, Turks, and Mohammedan negroes—write squatting on the carpet, or sometimes standing; the right hand, holding the pen, hangs free from the arm over the paper, and the arm is not supported. The left hand, also free in the air, or supported on the raised left knee, holds the paper stiff or laid on a little board. The right hand stays unmoved in the same place; only the fingers are put in motion for the shaping of the letters; while the left hand continually pushes the paper from left to right, so that the letters assume an arrangement from right to left, or in a centripetal direction. Thus the Shemitic people in writing perform movements directly opposed to ours. We hold the paper still, and move the hand; they move the paper, and hold the right hand almost still, as the Koran orders them to do.

An alphabet of two hundred phonetic signs representing syllables was invented in 1832, by a negro of the Vei tribe, who had learned to read from a missionary. He taught his people to write with a reed-pen and ink; but, while he wrote from left to right, the whole nation to-day write from right to left. If, as some believe, our centrifugal system of writing from left to right is founded on physiological considerations, the Veis would not have departed from it after having been taught in it.

M. Erlenmeyer accounts for the direction of the Shemitic writing on the supposition of its having been originally centrifugal, by assuming that these people first wrote with the left hand, to which the direction of their writing would be centrifugal, and afterward changed the hand without changing the direction of the writing. This is exceedingly improbable, for the Shemitic races consider the left hand impure, and regard writing as a holy act, which they never could have thought of performing with an impure instrument. Another explanation must be sought.

Holy acts, with the Shemitic peoples, are performed looking toward the east; therefore, in writing, those people would turn their faces to the east. The light would then come from the south, and the scribe would write from the light toward the shadow, from the unrolled part of his paper toward the roll which he is continually unrolling with his left hand. If he wished to write from left to right, he would require to have the roll in his right hand, and, in that case, the thicker the roll the more it would cut off his light and be in his way. The centripetal direction, from right to left, was then for the primitive Shemitic peoples, and still is for the Orientals, the only natural direction; it is founded

on the posture which the writer takes, his position with reference to the light, and the material he uses, and has become dominant by custom. Persons who are acquainted with the Eastern languages tell me that it would be as impossible for them to write in one of them from left to right, as it seems to be to write in a Western language from right to left; yet most of these persons learned to write in German or French before studying Hebrew writing. The direction in which we write, from left to right, is the most modern of all. It is common to all the Aryans, but was probably not adopted till after the emigration from the primitive countries. In the face of the facts we have mentioned, we need not ask why the Shemites write from right to left; but we should rather reverse the proposition, and ask why the Aryans abandoned the more ancient Shemitic direction, of which they doubtless had some knowledge. Whence did they get the centrifugal direction, from left to right? Difference in material does not account for the divergence; no more does difference in position, for the ancients were not acquainted with our table and desk. And even now, all French youth in the higher institutions write on a tablet supported on their knees, which is held by the left hand while the right hand holds the pencil, precisely as the Oriental writes, except that the paper is held still while the right hand moves—the converse of the Shemitic manipulation—and the direction of the writing is reversed. I have sought for information respecting the manner in which the ancient Aryans wrote in the absence of chairs and desks, without finding anything which could furnish an explanation of our mode of aligning the letters, so contrary to those of other peoples. The direction has become hereditary with us, transmitted from generation to generation, and our furniture, implements, and positions have become conformed to it. In setting our tables and adjusting our positions, we always seek to bring the light from the left, while the Shemite looks to the right for it. In both directions, centripetal and centrifugal, we write from the light toward the shade. If this is a general characteristic, and if, as we have sought to show, the primitive position of the writers depended on certain religious ideas, we may ask if there did not also exist particular religious reasons for the ancient Aryan method of writing.

My friend M. Charles Mayer, of Stuttgart, has remarked to me that the Aryans, in emigrating from their primitive home, followed the course of the sun, from the east toward the west. Their faces turned toward the setting sun, they had the noonday sun on the left. The left side, then, was the side of the light, of good luck; the right hand, the side of shadow and bad luck. The same signs had an opposite significance, accordingly as they appeared on one side or the other, in the inverse sense to that in which the Shemites regarded them. Have we not here a justification for the hypothesis that the Aryans turned their faces toward the west when they gave themselves to the holy operation of writing, and that, having the sun on their left, they

wrote like the Shemites, from the light toward the shadow, and consequently from left to right? If I insist so much on the primitive sanctity of the action of writing, it must not be forgotten that a close connection exists, even in our day, between the great religious domains and the method of writing. Buddhism, with all the Oriental religions of Asia which have preceded or followed it, writes from the top down; Islamism, the real continuation of Shemitism, writes from right to left; and Christianity, the emigrant product of Shemitism, which has left its father to settle among the Aryans, is scattering writing from left to right over nearly the whole world. Each of the three great religious groups has, then, a direction of writing peculiar to it.

I am far from meaning to pretend that all the questions are solved, and that the series of proofs I have presented is continuous. If I publish the results so far obtained, it is to excite interest and awaken discussion. But it seems to me to follow, from what I have said, that the direction of writing, the order of the letters and the lines, are in no way the forced consequence of a physiological cause, of a particular structure of the brain. I believe that I have proved, on the other hand, that the order of writing was primarily dictated by exterior causes, which, in many cases, may have wholly disappeared, but the result of which has been retained by habit and hereditary transmission. Our organization permits us to write with equal facility from the top down, from right to left, from left to right; no physiological condition has compelled us to choose a particular direction. If we select a determined order and drop the others, it is because we have learned to do so from our ancestors; and this order has been imposed on our ancestors in consequence of different external circumstances.

MODERN BASIS OF LIFE INSURANCE.

By THEODORE WEHLE.

WITH the year 1839 a new phase is reached in the first effort to tabulate the actual experience of insurance companies. Heretofore the average life of towns had furnished the data for mortality tables; now a table was to be deduced from observations of insured lives. Seventeen leading offices appointed a committee, to whom copies of their records were to be intrusted, which, owing to jealousies, were not as perfect as desirable. In 1843, after years of labor, a table was published, now known as "Actuaries' Experience Table No. 1." It was based on 18,282 policies, of which 7,372 had been discontinued, 4,786 had terminated by death, and 6,124 were still in force. The average duration of the policies under observation was eight and a half years.

In 1869 a table taking a far wider range was compiled, known as "Actuaries' Experience Table No. 2." It comprised the experience of twenty English and Scotch offices, all over twenty years old. It treats of 146,847 lives, which on an average had been under observation for ten years, and records 23,856 deaths. This table was not graduated until recently, and is only beginning to come into use.

About the same time Mr. Sheppard Homans published the "American Experience Table," based principally on twenty-six years' experience of the Mutual Life Insurance Company of New York. For the very young and old ages where the data were insufficient, he also made use of other American and English statistics. This table has been adopted as the official standard for New York and many other States.

The exact numbers and other details that served as a foundation for all these mortality tables have been given rather fully, at the risk of wearying the reader. The object has been to indicate the difficulties of obtaining them in a reliable and sufficient form, and on such a scale as to furnish trustworthy averages.

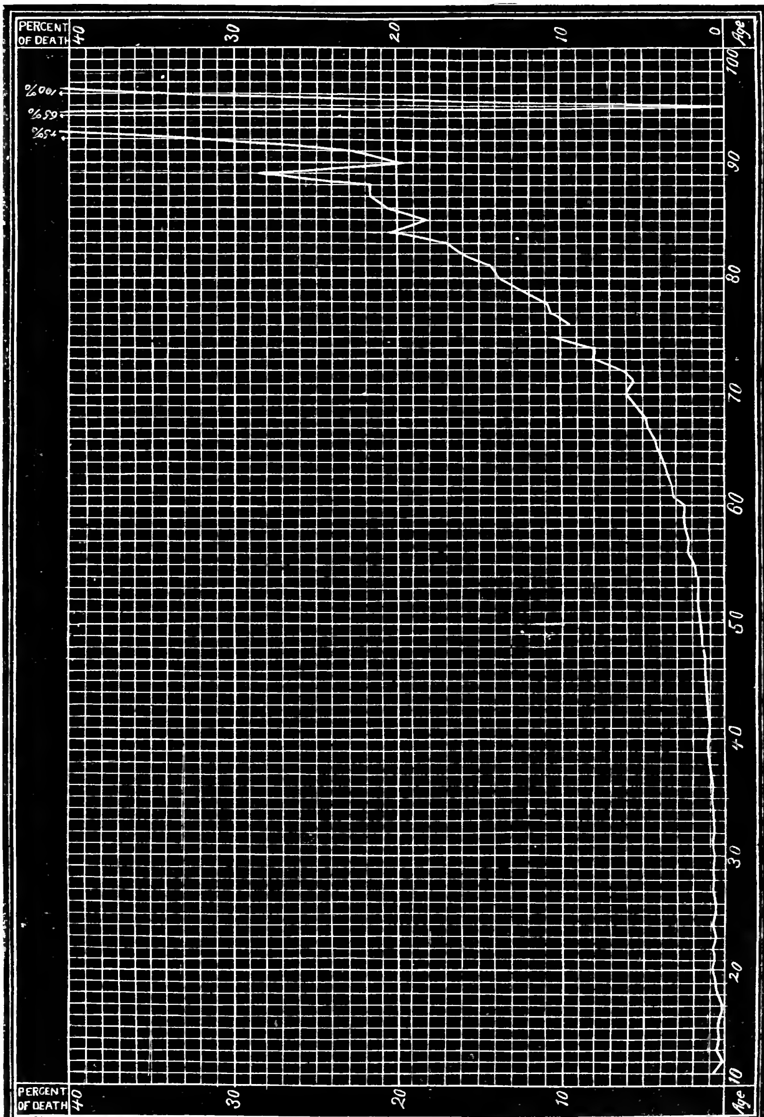
A little reflection will show that large numbers must be observed for a long term of years, to have deaths occur for every single year of life, and in the proper proportion for each age. Take as an illustration the Carlisle table based upon 1,840 deaths in eight years, which would average 230 deaths per year. According to the present mortality of England, about forty per cent. of the deaths of the whole population occur among children under five years old, forty per cent. between the ages of five and sixty-five, and twenty-per cent. in old age, between sixty-five and one hundred years. Apply these percentages to the 230 deaths at Carlisle, and they would give 92 persons dying under five years old, 92 between five and sixty-five years, and 46 between sixty-five and one hundred years of age. For the last thirty-five years of life only 46 deaths would be likely to take place, because, while the percentage of mortality is high, the number living at those ages is very small. But, when 46 deaths are distributed among thirty-five years of life, it is apparent that they are not likely to prove regularly divided among them. At some ages, and they may be the very highest, no deaths at all may occur. We know, however, that it is not in the course of nature that in any one year of life no human being should die, and properly ascribe it to the small number and the short space of time observed. Here the mathematician steps in and determines, from the insufficient data gathered, what the probable percentage of deaths would be for every year of life, in large communities living under similar conditions.

In illustration of what has been said, and as both interesting and instructive, the actual percentage of deaths comprised under the "Ungraduated Actuaries' Experience Table No. 2" is herewith given in graphic representation:

The table shows the remarkable fact that, out of so large a number

as 23,800 deaths, not a single individual died at ages eleven, sixteen, and ninety-four. This is due to the insufficient number of persons insured under twenty years, and the very small number living above

English Ungraduated Actuaries' Experience Table No. 2.



ninety years of age. The other most apparent fluctuations are a fall at age eighty-nine and a sudden rise at ages ninety-two and ninety-three. Here, again, for the same reasons, a very few deaths above or below the average cause large differences in the percentage. But

more or less deviation was experienced for almost every year of life, although the small scale to which the representation is necessarily confined does not clearly indicate it. The most superficial examination, however, must convince us that we are not dealing with accidents, but with a clearly pronounced tendency in the rate of mortality, disturbed only by minor causes.

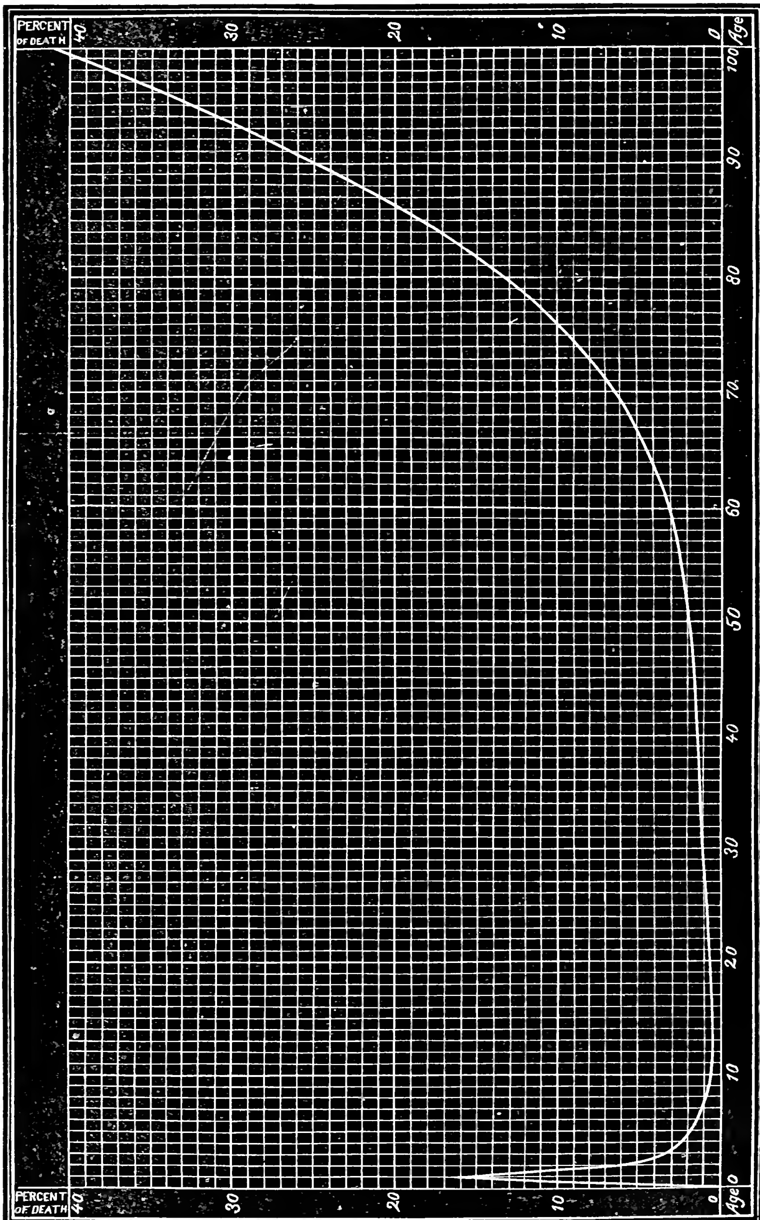
Leaving for the time life-insurance experience, for the wider field of vital statistics generally, we have to note a most important step, in the introduction of the decennial census in England in 1801, and the adoption of a system of registering deaths, births, and marriages, begun in 1836.

The data were thus collected for constructing a mortality table, embracing the whole population of England. This task was undertaken by the Assistant Registrar-General, Dr. Farr, on the census of 1841, and is known as "English Life Table No. 1." It is based on about 16,000,000 lives and 344,000 deaths. In 1863 he published a second table called "English Life Table No. 2," using the data of the census of 1841 and extending the deaths to three years previous to and three years subsequent to 1841. This period of seven years (1838 to 1844) furnished 2,436,648 deaths. Finally, in 1864, "English Life Table No. 3" was given to the public in the form of a distinct work. It was deduced from the two censuses of 1841 and 1851, and other records for the seventeen years from 1838 to 1854, embracing some 50,000,000 persons living and 6,470,000 deaths. Here, at length, we have a life-table on the largest scale, comprising the population of a whole country from birth upward. A graphic representation of the same is herewith presented, as that conveys a clearer picture to the mind than the reading of the numbers of the living and dying for every age.

On comparing Life Table No. 3 from ten years upward with the "Ungraduated Actuaries' Experience Table No. 2," it will be observed that the *direction* of the curve is very similar in both ; but, while the one is absolutely smooth and even, the other is disturbed by the more or less violent deviations already referred to. The process of removing these unevennesses in the line, actuaries call graduating or adjusting. It is a very delicate and most important problem, for it involves no less than the effort to determine the law of mortality, freed from the accidental influences which experience has recorded. The outline of this law is, indeed, clearly defined, and can be traced in every table—a high rate of mortality in the first year of life, decreasing until the minimum is reached somewhere near the age of puberty, then rising very gradually, until with old age a very rapid increase takes place. But, while these general traits are well established, the details are subject to continual deviations.

We must assume that there is a fundamental law of life accompanying the organization of the human being, but that it is fre-

ENGLISH LIFE TABLE No. 3.



quently traversed by many artificial and accidental influences. To determine the normal and eliminate the accidental conditions is the aim of theoretical inquiry. On the other hand, it may be urged that there is no normal standard of life nor of its surroundings, and that

length of life is merely an expression of the sum total of social influences upon the organism. A community may be divided into ever so many groups, each of which will have its peculiarity, and the summary of all these units will give as resultant the average of life. Every graduated mortality table may, therefore, be considered only an approximate expression of the death-rate under the conditions and at the time of observation.

We may now follow "English Life Table No. 3" more in detail. It gives a separate record of both male and female life, and we may examine the mortality of males first.

The notation adopted refers to the percentage of death in the current year; 0 meaning from birth to end of first year, 1 from beginning to end of second year of life, and so on:

Age.	Percentage of deaths.	Age.	Percentage of deaths.	Age.	Percentage of deaths.	Age.	Percentage of deaths.
0	16·36	15	·52	40	1·30	70	6·73
1	6·40	20	·83	45	1·54	80	14·18
5	1·36	25	·92	50	1·88	90	26·41
10	·56	30	1·00	55	2·45	95	34 21
13	·47	35	1·13	60	3·25	100	41·78

The table ends with age 107.

Taking birth as a starting-point, the mortality for the first 5 years of life is 27·64 per cent.
" " " " " " " 10 " " 31·02 "
" " " " " " " 20 " " 34·82 "
" " " " " " " 44½ " " 50·00 "

The rate of mortality of age 5 is again reached at about age.................... 41
" " " 1 " " " "........................ 70
" " " 0 " " " "........................ 82

About 1 in 4½ of all children born will reach age............................ 70
" 1 " 10 " " " " "............................ 78
" 1 " 100 " " " " "............................ 90

Let us now compare male and female mortality. There are born 511,745 males to 488,255 females, being an excess of 23,490 males = 4·81 per cent.

During age 0, the deaths are 83,719 males to 65,774 females: leaving males in excess.... .... 1·31 per cent.
At " 8..............................the excess of males living is 1·00 "
" " 15.............................. " " " 1·18 "
" " 37.............................. " " " 2·08 "
" " 50.............................. " " " .93 "
" " 53....................the sexes are about even in number.
" " 70..............................the excess of *females* living is 8·00 "
" " 80.............................. " " " 19·00 "
" " 90.............................. " " " 41.00 "

End of table for male life is 107 years, for female life is 108 years.
Equation of " " 44½ " of " " 46½ "
Of males living at age 20, about 1 in 3 will reach 70 years, of females 1 in 2⅔.
" " " " " 1 " 8 " " 80 " " 1 " 6¾.
" " " " " 1 " 70 " " 90 " " 1 " 49.

Thus it appears that, with the exception of the period from fifteen to thirty-seven, where the larger mortality can be easily explained on physiological grounds, females have a far better chance of life than males. This is particularly marked in the first year of life, and after fifty-three years of age.

Some of the results deduced from this table will no doubt surprise many. It is not commonly assumed that age thirteen is the healthiest in life, or that so large a proportion of infants will reach as high an age as is here indicated. Nor is it generally known that more boys are born than girls, and that the weaker sex has such decided advantages in life over the stronger. But, while nearly five per cent. more male than female infants are born, the very reverse appears in the whole population, there being about five per cent. more females living than males. Of course, these proportions refer to England only, and they vary in different countries, according to conditions and influences that the reader can readily picture to himself.

English Life Table No. 3 marks an epoch in statistical science, and the results obtained are valuable and sufficiently reliable for practical purposes, but much yet remains to be done to satisfy scientific inquiry. An annual census, which is strongly urged, would allow a closer and more frequent examination of facts, and reduce mathematical speculation to a minimum.

One question of grave importance can not yet be considered as definitively settled; it is whether the rate of mortality is steadily declining, and the duration of life is correspondingly extending. In a general way, and as compared with former centuries, there can be no doubt that a marked improvement is to be found. Take the population of England as an illustration:

It was estimated in 1651 at	5,450,000
" " 1751 at	6,400,000
Census of 1801 at	8,892,536
" 1851 at	17,927,609

This shows an increase of seventeen and a half per cent. for the century from 1651 to 1751, of thirty-nine per cent. for the fifty years to 1801, and of one hundred and one and a half per cent. for fifty years to 1851.

These rapid strides are not astonishing when we consider the epidemics, the internal strife, the famines, and insufficient means of communication, the disorderly and unsettled habits of former times, and compare them with the better hygiene, the greater comforts, and the generally refining influences of the present. But this increasing ratio of growth may be due either to a larger percentage of births, or to a smaller proportion of deaths, or to both causes combined. Statistics seem to indicate that both factors are even now contributing to this result. In 1841, out of 1,000 of the population, 15·4 were married dur-

ing the year, and in 1876 the number had gradually risen to 17 per 1,000. So that, in spite of large cities and the greater difficulty of supporting families, the growing tendency to settled and more regular habits is exhibited in the larger number of marriages. The result is an increasing number of births in proportion to the population. In 1841, 512,158 children were born, being 32·2 per 1,000, while in 1876 the number was 887,464, or 36·6 per 1,000, which is an increase of about twenty-five per cent. The deaths, on the other hand, remained nearly stationary, being 21·6 per 1,000 in 1841 to 21·9 in 1876. The ratio of deaths to births, therefore, stood as 1 to 1·49 in 1841, while in 1876 it was as 1 to 1·74.

The preponderance of young families, however, ought to make the death-rate very much higher, as the mortality at the young ages is very large. Since it remained nearly unchanged, while the marriages and births increased, it would indicate that the average duration of life was being extended. For special localities like large cities, it is well known that sanitary measures and other causes are producing constant improvement; but there are many counteracting conditions to be considered. With an improved system of registration and more frequent enumerations of the people, data will be obtained for computing and comparing life tables at shorter intervals, and there can be no doubt that, in spite of increasing difficulties, the beneficial influences of higher civilization will be found to tend to a steady prolongation of human life.

Recurring after this digression to the experience of life-insurance companies, we will compare English Life Table No. 3 from twenty years upward with the two tables most in use, the Actuaries' Experience Table No. 1 and the American Experience Table. The percentages are given, in preference to the number of living and dying for each period:

AGES.	ENGLISH LIFE NO 3.	ACTUARIES' EXPERIENCE NO. 1.	AMERICAN EXPERIENCE.
	Percentage of deaths.	Percentage of deaths.	Percentage of deaths.
20	·83	·73	·78
25	·92	·78	·81
30	1·00	·84	·84
35	1·13	·93	·89
40	1·30	1·04	·98
45	1·54	1·22	1·12
50	1·88	1·59	1·38
55	2·45	2·17	1·86
60	3·25	3·03	2·67
65	4·59	4·41	4·01
70	6·73	6·50	6·20
80	14·18	14·04	14·45
90	26·41	32·37	45·45
95	34·21	58·43	100·00
99	41·04	100·00	.....
107	100·00	.....	.....

While the two experience tables are very similar, and represent about the same social conditions, the well-to-do middle classes, in this country and in England, the American table has a peculiarity characteristic of life in the United States. At the younger ages, up to thirty years, the mortality is greater, while from thirty to seventy years it is somewhat less than in England. During this latter, the most active period of life, the strain upon the system is very great in this country, and the vital forces are used up to such an extent that after seventy years the death-rate rises rapidly. The table ends at ninety-five, while the English is carried to ninety-nine. It may also be mentioned here that female life has proved less favorable than male life to insurance companies, while it will be remembered that the very reverse has been observed in the community at large. The next point that will attract attention is, that the English life table, representing the average life of the whole population, does not range so much above the insurance tables as might be supposed. Insurance companies select only healthy individuals by medical examination, and almost exclusively from the better classes and occupations. Why, then, is the difference not greater? Some of the reasons can be readily given. First, there is a constant effort on the part of the public to foist impaired lives upon the insurers. No amount of care or precaution can detect all misrepresentation or trace every inducement to fraud and self-destruction, and, while it may amount to less than some assume, it undoubtedly reduces the standard of absolute health. Of far greater importance is the observation that the effect of selection nearly wears away in about five years. Taking a class of lives selected by medical examination, say at twenty-five years, it will show a reduced mortality during the first year; but after five years, at age thirty, very nearly the usual average is again reached. For, while the diseased are excluded from the selected class, a certain number of these sound lives will find their health to fail from year to year. Were those admitted at twenty-five years to be reëxamined at age thirty, so many sick and ailing would be among them that the advantages of selection would be found to have largely disappeared.

Registrar-General Farr estimates 27 out of 1,000 of the whole population, between the ages of twenty and sixty, to suffer from some kind of disease or other, be it hereditary, chronic, recurrent, or acute. Consumption, he thinks, though varied in duration, seems to average about two years. The higher the age, the greater the value of selection; and, the older the members of a life-insurance company become, the more do they approximate the health of the community at large.

Another factor that operates as a selection against the mortality experience is what is called lapses. A large number of policies are constantly allowed to terminate through the indifference of the insured, and for various other reasons. But, while the healthy often forfeit

their insurance upon slight provocation, there are few indeed, of those that think their health impaired, that will do so. The result is, that an undue proportion of the sickly will remain, and exert a deteriorating influence upon the average mortality.

Finally, it must not be forgotten that there is, after all, a considerable difference in the middle ages between the English life table and the insurance tables, particularly the American Experience Table. This latter, Mr. Homans states, has the effect of selection carefully eliminated, and therefore indicates a higher rate of mortality than the actual experience. As a matter of fact, all well-managed insurance companies, doing a sufficiently large business to furnish the basis for reliable averages, and having a constant accession of *new lives*, experience more or less gain over the tables in use.

Before dismissing this subject, one question of a general character yet remains to be answered, viz., how do, or may, epidemics affect the average rate of mortality?

As regards the possibilities of the future, it is strictly a problem for medical and sanitary science; but we may be allowed to draw some inferences from the past records of a well-ordered state.

In 1849 a cholera epidemic, of a very malignant type, prevailed in England, considerably increasing the mortality for that year.

The number of deaths for the five years from 1848 to 1852 were as follows:

1848	398,385
1849	440,883
1850	368,602
1851	395,396
1852	407,135
	2,010,401

It will be noticed that in 1849 the increase over the previous year was about 42,000, while in the following year, 1850, there was a falling off to 30,000 below the number of deaths in 1848. For the period of five years from 1848 to 1852 the annual average of 400,000 remained undisturbed. This would indicate that, when through a powerful influence an excessive death-rate prevails, a large proportion of the weak and sickly is carried off, so that by way of compensation the surviving, healthier population will for a time show a mortality below the average. It is also well known that such inflictions are largely confined to the dirtiest and most crowded quarters, and carry off principally the poor and improvident. As these classes do not insure their lives, the mortality experience of insurance companies is no more likely to be seriously affected by epidemics in the future than it has been in the past.

STATE EDUCATION: A NECESSITY.

By CHARLES S. BRYANT.

IN the September number of "The Popular Science Monthly," 1880, appeared an article, reprinted from the "Fortnightly Review," entitled "State Education : a Help or a Hindrance?" It was written by the Honorable Auberon Herbert, an English writer of more than ordinary ability. He opposes state education on principle ; and, as much of his reasoning applies in this country as well as in England, it is desirable that his fallacies should be exposed in the same journal that has given them currency here. The writer has neither limited his remarks to the English system, nor confined himself to obnoxious methods of applying courses of study to the education of the young in England or elsewhere. Had he done either, a writer on this side the Atlantic might have hesitated to question the propriety of his convictions. But, embracing, as he seems to do, the whole field of organized state educational effort, he has opened a theme as broad as the foundations on which society rests.

Some of his conclusions present points on which eminent educators, both in England and in America, widely differ. A note at the bottom of the first page of his article may have some modifying effect upon his radical conclusions. This note is in the words following : "I ought to say that I have changed my opinions as regards the action of the state since 1870. I would not have made this change without the assistance of Mr. Herbert Spencer's writings."—("Popular Science Monthly," vol. xvii, p. 585.) Mr. Spencer, to whose writings our author refers, has written many able things on education, with which educators are well agreed ; but he is not understood in this country to be wholly opposed to state education. And it may be suggested that the disciple may differ with his teacher, or that the teacher may himself be misunderstood in the application of his principles to particular conditions of the social status. The conditions of the state, also, must be continually advancing beyond the demands of earlier efforts, as society in its tastes and needs moves forward. State growth has no limit, and hence no rule can be laid down for the government of the future that does not embrace the possibility of new combinations. The Spencer of to-day may predict, but the Spencer of to-morrow may find the historic progress in conflict with his prediction. Man's needs in his social and civil relations, in his artificial progress, can not be determined with the precision of mathematical certainty, as we determine the movements of the planets.

The English Government, of which the writer of the article under consideration is an integral element, is rapidly changing its position on the question of state education. The question with his country

seems not now to be, whether state education shall be inaugurated, but rather what kind it shall have. The state must retain control of all the elements necessary to its life. The educational element the state can not intrust to any organism beyond its control. Sovereignty must control the education which is the life and soul of the state.

The discussion on Sir John Lubbock's bill in the British Parliament, of recent date, was in relation to the studies to be introduced into the curriculum, rather than the question of state interference. An extract from "Nature," an English print, will set this matter in its proper light:

"It is unnecessary," says the writer, "for us to go again into the merits of the question which has been so often and so thoroughly discussed in these pages, especially as the 'Times' has put it quite as forcibly as there is occasion of doing at present. It certainly seems sad, nationally, indeed, that a few more millions of those who will have the destinies of this country in their hands are likely to be launched into active life, with all their education to acquire, ere legislation steps in to give us the advantages which nearly every other civilized nation gives to its children. Every day we hear of the ignorance of the working-classes, every other month 'congresses' are held to devise means to remedy the consequences of this ignorance: ignorance of the laws of health; ignorance of household economy; ignorance of the implements and objects of labor; ignorance of the laws of labor and production; ignorance of the nature of the commonest objects with which they come into contact every day; ignorance of almost everything which it would be useful and naturally beneficial for them to know; an ignorance, alas! more or less shared by the 'curled darlings' of the nation. Yet every day's paper shows how keen is the industrial competition with other nations, and how in one department after another we are being outstripped by the results of better—i. e., more scientific—knowledge; the poor pittance of 'elementary knowledge' asked for in Sir John Lubbock's bill is refused by a minister* whose own education leaves much to be desired. This state of things can not long continue, and, with such advocates for the children as the 'Times' and Mr. Forster, we may hope that next time Sir John Lubbock brings forward his bill it will meet with a happier fate."—("Popular Science Monthly," vol. xiii, pp. 562, 563.)

The truth expressed in the above quotation, that England, holding one of the most advanced positions of the human race, is yet being outstripped in one industry and another, in one department after another, "by the results of better—i. e., more scientific—knowledge," can not fail, in the reflecting mind, to suggest another truth: that civil society is a constantly developing organism, the range of whose future specialties must remain unknown. Yet through all, in the line of its direction, it is evident that some power must control. This

* Lord George Hamilton.

power must be the sovereign will. The *Cloister* and the *Castle*, the *Church* and the *State*, at different stages have severally presented their peculiar claims to wield the scepter of education. And the *supreme control* is now, in England and in America, fast passing from the Church to the state. Is the growth in this direction sound and normal? The integral elements certainly have more freedom, the intellectual powers more activity, and the forces and laws of nature are made more thoroughly subservient to the wants of the whole. We can not, therefore, say that in this direction the movement is abnormal, or that a result of a disastrous character will arise. The state organism indeed seems, so far, the most efficient. And England, believing in its healthy growth, even in elementary knowledge, now makes a strong appeal, not to the Church but to the state (not in its unorganized elements, but in its sovereign capacity) for the education of *all her people.* Is the appeal unwise? Can the results be anything but beneficial?

It is safe to believe that as human society advances it develops step by step relations of a wider, better, and different character; transferring responsibilities once peculiar to the lower to the next higher relation. The child of the family in turn becomes the man of the tribe, and the member of the tribe becomes the citizen of the state or nation. In this forward movement the family may have had absolute control during the age of childhood. In the next stage parental government is modified, or terminated, and yields to the dominant claims of the tribe. In the still wider national relation, the tribal government, embracing whatever there may be of culture in war and peace, at once yields to the supreme demands of the state or nation.

The child passes in any organized society through all the grades in the related social state. In the same order also government passes on, until it rests in the control of sovereignty, *the state.* And the right of the state to the custody and control of the citizen is as complete as the right of the parent to the control of the infant child. These are only the natural laws belonging to the several relations in the growth of society in all artificial conditions, under all governments. State control, therefore, comes into rightful exercise of authority over the education of every human being entitled to the privileges and protection of government. The particular age at which state authority may rightfully interfere in this relation is a matter of state policy and sovereign discretion.

All arguments, therefore, of the writer against either the right or the policy of the state, in exercising control over the education of the subject, rest upon a theory quite erroneous, upon the superior right of the parent over the control of the entire education of the coming citizen of the higher organization.

Mr. Herbert asks the pertinent question, "Could education be supplied without official assistance?" This question he answers in the

affirmative. His answer might be correct if confined to *some kinds of education*. But he does not seem to consider that the education conducted without official or state assistance, permission or direction, may be entirely opposed to the best interests of the state, and, indeed, subversive to its organization, and thus fall short of *the kind* of education required for the very existence of the state. Had he asked the more vital question, "Could education, such as is required for the existence of the state, be certainly supplied without state direction or official assistance?" the writer would hardly have answered that "the kind of education required could well be supplied without state direction and state authority." And it would seem that the real question for England and America to answer is, Will voluntary, individual, or associated parental authority at all times sustain the education required by the state? And still further, Will the education furnished by voluntary effort be equal to the demands of the successive generations as they come and go? To provide this, some authority must interpose some organized system of supervision, as active and continuous as the life of the government, and as extensive as the demands of the generations passing through the required course.

State education, then, is not only not a hindrance, but a necessity. state aid, however, in education is of wide application. It may not be necessary for the state to pay for education out of the state treasury, and still it may necessary to regulate by law some system of uniform public instruction. It may be necessary for the state to allow local taxation for the education which, without law, they might demand in vain. It may be necessary for states to allow, by statute law, a graded system of education, culminating in a university course. If the child is required to be educated in some particular way, he certainly should have the legal right to demand the time to acquire it, and the course of study legally defined. If he is allowed a time to acquire the state education, he should be allowed the necessary instruction during the time. These are correlative relations.

On no individual or associated plan, of a voluntary character, can education be supplied to the entire people, such as the state can rely upon for its own existence. It would take generations to give it even a partial existence in the most favored communities in the most advanced governments. At no one period could the voluntary plan apply the requisite culture to the entire masses passing the age of school culture. And to this conclusion the honorable gentleman seems himself to have come when criticising the present English attempt to introduce a national system. He says: "No truly great thing grows like a mushroom. An intelligent value for education can only spread slow, like civilization itself. In our hurry to act, we have not seen how much life and movement is sacrificed to make place for an official system. Those who administer such systems wish to get the flower ready made without any process of growth."

The voluntary plan has been tried by England ever since the island came under one rule. And this mode of application was not only not interfered with, but actually encouraged by the state. Immunity from certain punishments was granted to the man who could read. Even this low species of education was rewarded by the state with the title of "*clerk*, though neither initiated in holy orders nor trimmed with the clerical tonsure."—(Blackstone's "Commentaries," vol. iv, p. 366.) And, after this long reign of voluntary effort, encouraged for centuries by the state, and supplemented by the coöperative principle, the nation is now driven to assume the duty, as it has ever had the right, to control the educational system demanded not only by the parentage but by the whole people. Private efforts, individual and associated labors, all personal benefactions, and various national foundations, have severally exerted the voluntary and in part the coercive methods of education, and, under the most effective operation of them all combined, the national illiteracy has not been diminished, but is rather increasing with the growth in population. How, then, can this system, or, properly, no system, be relied on? With it, can England apply to practical demands the education which the slow growth of the ages has made ready for her hand? It is less a question how to create, than how to apply the knowledge now ready for the hungering masses.

Mr. Herbert objects seriously to state education, because "forced payments taken from other classes place the workman under an obligation; that, in consequence, the upper and middle classes interfere in the education of his children; that under a practical system there is no place for his personal views."

Now, it is hard to see how a tax for the education of the children of the workman should be more likely to create a feeling of obligation toward the tax-payer than would necessarily exist in any other case of taxation for the support of government, standing on the same legal foundation as a tax for education. Why should the feeling of obligation oppress the *royal family*, to know that *royalty* is upheld by a forced levy upon the property of the lords and landholders of the realm? It is certainly not such a feeling of dependence as the *royal family* wishes to discard. Royalty can certainly endure the strain quite as long as the tax-payers desire to continue the relation. But the feeling of obligation does not, in fact, exist between the workmen of England and the class taxed for education, while in this country, from the nature of our political society, it is not only unknown, but an impossible thing.

Labor, in all departments, physical and intellectual, working as a unit, produces a reservoir of wealth. This reservoir of wealth is *leisure*, a fund common to all, in which all are interested to the extent of their wants, natural or artificial. In the production of this common capital, the *laborer*, in the first form of production, is an essen-

tial ingredient. Without him the reservoir would contain nothing. And every worker of the series required to swell this reservoir of wealth has an interest in the end to be attained, and in every contribution to that end. The workmen embrace nearly every member of the national family. The interdependence is complete; and the obligation felt is not the kind to be avoided, but ought to be agreeable, mutual, and brotherly. However, a little inquiry will satisfy any one that the laborer feels that the world owes him quite as much as he owes the world. This argument, drawn from dependence and obligation, has no application in the family or in the nation. Analogies in *nature* are everywhere at hand. If any part of its articulated order fails, the whole is affected:

> "In Nature's chain, whatever link you strike,
> Tenth or ten-thousandth, breaks the chain alike."

So with the related order of society rising from native savagery to its highest artificial conditions.

A tax for education, considered from another point of view, might be properly regarded as a police regulation; and governmental action, state or national, rigorously and systematically applying it to the reduction of ignorance, that worst foe to a free people, viewed as a vital step toward securing the public safety.

Uniformity.—But uniformity is objected to, by Mr. Herbert, as an evil in the English system; and, if so, it would be the same in any other country. Such a system, he believes, is not sufficiently elastic, and does not yield readily enough to improved methods of instruction. Teachers and pupils and trustees go alike into the groove of established routine, and there remain, to the injury of the mental growth of all, and thus become a positive hindrance to progress. "Changes," he says, if ever made by great exertions, "would be only spasmodic; they would not be the natural outcome of the system, and therefore could not last."

It can be replied to this objection, that *uniformity* is but the precursor of variety, and without intelligent uniformity there can be no sure foundation for progress. We, indeed, expect the greatest variety from the most perfect uniformity and regularity in the systems we are investigating. Were there no laws of uniform operation in nature, we should have no foundation for science, physical or psychological; and the most perfect uniformity is yet so prolific in variety that the fields of human investigation are infinite.

But we have only space for one practical illustration of this principle of uniformity. We have, in America, a system of schools, either permitted by license from the State, or required by State enactments, which is quite as uniform a system as exists in England, and perhaps far more so. And the uniformity of the American system of graded free schools, for the forty years of their operation, has not as yet

presented any of the special or general evils so much feared by the honorable gentleman, and which to him seem so threatening in the schools of England. In several of our American cities the system has matured, during a period of some thirty-odd years, from the kindergarten to the university. These schools have produced whatever results the organism of the graded system is calculated to accomplish. The pupils have passed from the lowest grade, in regular order, in large classes, under similar programmes, in a uniform course, supervised by boards of trustees, and taught by instructors rising in literary attainments from grade to grade through the entire series. When the higher grades are reached, the pupils take more and more *optional* studies, and less and less *required*. And, as the curriculum widens toward the end of the course, the linguistic and scientific studies yield more and more to the inclination of the parent or the pupil, until the post-graduates of the high-school, as well as of the university, severally fall into chosen specialties, as their tastes and preparation may dictate. The result is all that could be desired. So independent and so varied are the subjects of this uniform, organized system of required and optional studies, and so thorough is the knowledge imparted in the selected fields embraced in its curriculum, that from one city its fame has passed from the Western to the Eastern Hemisphere, and in several important lines of skilled industries and art-culture received the award of superiority at the late Paris Exposition over the schools of the civilized world!

At the expense of a little brevity, let me here make a short quotation from a report of Superintendent Peaslee, of the Cincinnati schools, under date of 1880. He says: "I desire to call the attention of the board to the statement of the National Educational Association at Washington, in February last, by Hon. J. D. Philbrick, U. S. Commissioner to the Paris Exposition, and former Superintendent of the Public Schools of Boston. In speaking of the different school exhibits at Paris, Mr. Philbrick said, 'No other exhibits of scholars' work equal to that of Cincinnati was ever made in the known world.' It will be remembered that Mr. Philbrick was also United States Commissioner of Education at Vienna, in 1872, and that he was connected with the educational exhibit of the Centennial Exhibition at Philadelphia. 'In this connection,' he says, 'it gives me great pleasure to report that I have received, through the United States Commissioner, General R. C. McCormick, a gold-medal diploma and a silver-medal diploma, awarded to the public schools of Cincinnati, by the international jury at the Universal Exposition of 1878 held at Paris. I have had the gratification, also, of receiving from the Royal Industrial Museum at Turin a diploma of membership, as a token of their appreciation of the work of our school exhibit at Paris. As stated in a previous report, Cincinnati enjoys the most complete system of public-school education of any city in the world; for the pupils

of both sexes have not only open to them the advantages of the district, intermediate, and high schools, but possess the privilege of attending, free of charge, the University of Cincinnati. The course of instruction in their long-extended curriculum is of a very high character. From school to school the student passes, till he goes out into the world from the university with the broad teaching which will make him hold his own proudly in the stirring times in which we live."

In what this school is, as an organic element, preparing in American cities, we see in miniature the still wider organization growing up in the several States, preparatory to the completed national organization of the ideal American System of Graded Free Schools. The cities, in the American State school system, under State law, by means of local levies, limited to the property of the city or district, with scarcely an exception, have built up this class of schools. The common school, with its corps of teachers, is followed by the high-school, with higher instructors and added supervision, and this again by the university, either for the city or the State, with a still higher order of instruction and supervision; and the organism is complete, each element in the series working apart but in harmony with the whole.

But finally we come to the religious question, which the ingenious objector to state schools has arrayed in its full force. Both in England and in America this question continues, to some extent, to be a disturbing element in the school problem. Mr. Herbert is not entirely free from the mist which this element creates in all sectarian atmospheres. He gives expression to his convictions in the following explicit language:

"I can not escape a few words on the much-vexed religious question. Under our present system the Nonconformists are putting a grievous strain upon their own principles. Whoever fairly faces the question must admit that the same set of arguments which condemns a national religion also condemns a national system of education. It is hard to pronounce sentence on the one and absolve the other. Does a national Church compel some to support a system to which they are opposed? So does a national system of education. Does the one exalt the principle of majorities over the individual conscience? So does the other. Does a national Church imply a distrust of the people, of their willingness to make sacrifices, of their capacity to manage their own affairs? So does a national system of education. Does the one chill and repress the higher meanings and purposes of formalism? So does the other."

The contrast between a national Church and a national system of education is quite clear to all persons, although there are several points of resemblance in their application. The two curricula are different in all those peculiar specialties in which each has its appropriate

sphere. One relates to temporal and the other to spiritual matters; and hence one embraces the great truth that the citizen should "render unto Cæsar the things that are Cæsar's"; the other, that he should render "unto God the things that are God's." The organisms that administer these curricula must necessarily differ. The comprehensive specialty of the Church is *faith* in a revealed religion. This, according to each sectarian creed, must be taught by the Church. The distinguishing specialty of the state is *law*, and obedience to this arbiter is the foundation on which the "life, liberty, and the pursuit of happiness" are guaranteed to the citizen, and must be taught by secular schools, either permitted directly or aided by the state. These organisms have each a special work. And while the state could teach religion as well as the Church could make and enforce laws regulating all state matters and the duty of the citizen, in doing this, each must necessarily abandon its own specialty; so that, while these organisms exist separate, as in America, each must pursue its own specialty. In no other way can the proper support of the several arbiters be maintained.

The argument, therefore, of Mr. Herbert, above quoted, against a national system of education for the reasons stated or implied, is unsound, and of no possible application. He has presented no argument against a national system of education that would not apply as well in in any other case of enforced taxation. Substitute a national system of imposts, a tariff, instead of a national system of education, and ask his questions, and the same answers must be given. Thus: "Does a national Church compel some to support a system to which they are opposed? So does a national system of imposts. Does the one exalt the principle of majorities over the individual conscience? So does the other. Does a national Church imply a distrust of the people, of their willingness to make sacrifices, of their capacity to manage their own affairs? So does a national system of imposts." Now, it is evident that the results here arrived at prove nothing more than this: that an enforced tax, however imposed, must necessarily result as stated; some will be opposed, majorities will be exalted, and even some slight foundation afforded for the startling implication of distrust in the voluntary action of the people, as a whole, in the matter concerned.

But we can not conclude that this religious argument in any way militates against the argument in favor of national education. The argument in favor of a national tariff, though oppressive to some, is only such oppression as minorities must endure in any species of legislation, whether for the promotion of virtue or the suppression of vice. But there is still a more complete answer to this religious argument, as used by Mr. Herbert. Over matters of *conscience* the higher law has dominion; but only over intentional acts has human legislation any rightful control. The control of men's actions lies *within*, but

the control of men's consciences *without*, and beyond, the scope of human legislation; so that state education is a legitimate subject of state control, while the support of a national Church is altogether beyond the sphere of national authority.

THE BLOOD AND ITS CIRCULATION.*

By HERMAN L. FAIRCHILD.

IN vertebrates alone is there a closed circulation—a complete system of tubes from whence the blood never escapes into the body-cavity. We find an approach to it in the higher mollusks. Indeed, in power and general efficiency, the circulation of the highest mollusks is greatly superior to that of the low vertebrates. Nevertheless, the perfectly closed circulatory system of even the lowest vertebrates is of higher type. Although the circulating system of the vertebrates is perfected in principle, it still admits of very great and curious modifications.

There exist in vertebrates three sets of capillary blood-vessels, which are usually spoken of as three systems, although together they constitute but a single circuit. They are distinguished as the body or systemic circulation, the respiratory or pulmonary circulation, and the liver or portal circulation. Connected with the blood-system by the thoracic duct is the lymphatic circulation.

The lymphatic system, which has previously been mentioned as the second source of blood material, deserves some notice on account of its intimate relation with the blood system of the vertebrates. The lymphatics are minute capillary vessels, found in all parts of the body of vertebrates, excepting, perhaps, the bulb of the eye, the cartilages, and the bones. They unite to form, with the lacteals, the *thoracic duct*, which was described in the article on digestion, in the September number of the "Monthly."

The office of the lymphatics is to collect the waste matter of the tissues and return it to the blood, to be again used elsewhere, or, if wholly useless, to be excreted from the body. They also collect the blood which may be poured upon the tissues in excess of their needs. The fluid which the lymphatics carry is called *lymph*. It is colorless, and contains corpuscles resembling the white corpuscles of the blood.

The lacteals, which take the new food from the intestines, are lymphatics modified for a special purpose, and, when they are not busy with the chyle, they also carry lymph.

The lymphatic tubes are provided with valves to keep the lymph flowing toward the larger trunks.

* Concluded from page 468.

This lymphatic system of the vertebrated animals is, however, expressed in technical language, only the differentiated interstitial sinuses of the lower animals, which has, in the latter, a share in the venous circulation. Indeed, in the lower vertebrates the lymphatic tubes frequently assume the form of large sinuses, and connect with the veins. They are even found in the birds. In the frog four of these sinuses have muscular walls, and rhythmically contract. These are known as lymphatic hearts.

In various parts of the body the lymphatics form glands, such as the thymus, thyroid gland, and the spleen.

Fishes have a heart resembling that of the mollusks. It is a double force-pump, consisting of a receiving-chamber (auricle), and a propelling chamber (ventricle), with all the valves necessary to prevent a backward flow of the blood. But this heart is respiratory--it sends the blood directly to the breathing organs ; consequently, it passes only impure blood. When the blood has traversed the gills and is purified, it passes around the circuit of the body through the systemic and portal capillaries, and back to the heart without any further propulsion.

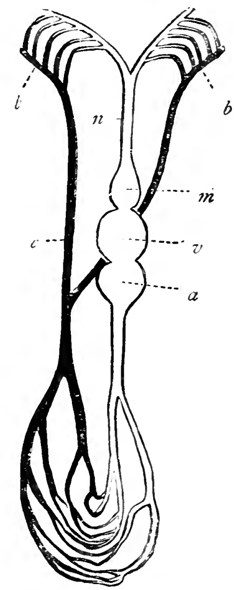


FIG. 1.—DIAGRAM OF THE CIRCULATION IN A FISH. (The portion of the system containing pure blood is black; the part containing impure blood is white.) *a*, auricle, receiving venous blood from the body ; *v*, ventricle; *m*, bulbus arteriosus ; *n*, branchial artery, carrying venous blood to the gills (*b*, *b*): *c*, aorta, carrying arterialized blood to all parts of the body.

The low, worm-like fish, lancelet, or amphioxus, has no special heart, but a number of contractile bulbs in the veins. The eel has such an auxiliary heart in its tail, while the hag has the circulation aided by the contractility of the portal vein.

Lepidosiren, one of the mud-fishes, approaches the amphibians in the possession of two auricles ; for, in addition to gills, it has true lungs. The vein conveying the purified blood from the lungs joins the left auricle.

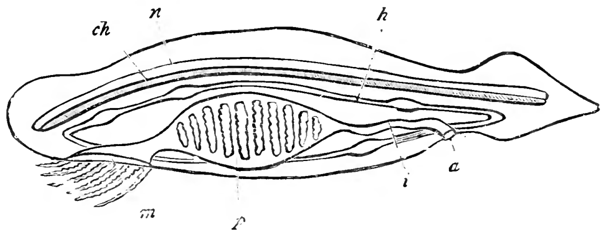


FIG. 2.—DIAGRAM OF THE LANCELET (*Amphioxus*). *m*, mouth, surrounded by cartilaginous cirri ; *p*, greatly-dilated pharynx, perforated by ciliated clefts ; *i*, intestine ; *a*, anus ; *h*, blood-system, with pulsating dilatations ; *ch*, notochord ; *n*, nervous cord.

Amphibians and reptiles exist under conditions incompatible with a high temperature of the body. In the adult state they are air-breathers, and, if their circulation were complete, they would be "warm-blooded." But the temperature is subdued by imperfect circulation, which results from the arrangement of the heart-chambers. There is but one ventricle for the two auricles, hence the pure blood from the breathing organs and the impure blood from the body are mingled, so that, besides the venous and arterial, they have a mixed blood. The blood which goes to the lungs is never wholly impure, and that which goes to the body is never entirely pure. However, by a complex and beautiful action of the parts and valves of the heart—too complex to be here described—the mingling of venous and arterial blood is not complete.

The change which the amphibians undergo in outward form, from the tadpole or larval state to the frog-like condition, is accompanied

Fig. 3.

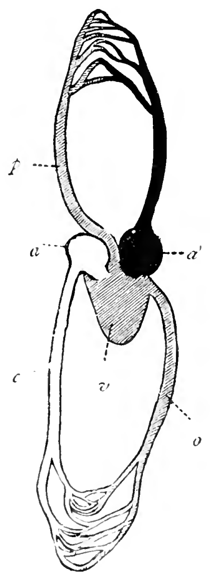


Fig. 4.

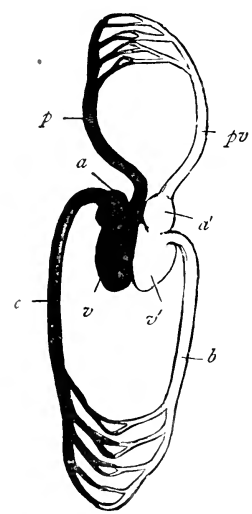


Fig. 3.—Diagram of the Circulation in a Reptile. (The part containing pure blood is black; that containing impure blood is white; and that containing mixed blood is cross-shaded.) *a*, right auricle, receiving impure blood from the body; *a'*, left auricle, receiving pure blood from the lungs; *v*, ventricle, containing mixed blood, which is carried by the pulmonary artery (*p*) to the lungs, and by the aorta (*o*) to the body.

Fig. 4.—Diagram of the Circulation of a Bird or Mammal. (The venous system is black; the arterial system is white.) *a*, right auricle; *v*, right ventricle; *p*, pulmonary artery, carrying venous blood to the lungs; *pv*, pulmonary veins, carrying arterial blood from the lungs; *a'*, left auricle; *v'*, left ventricle; *b*, aorta, carrying arterial blood to the body; *c*, vena cava, carrying venous blood to the lungs.

by a remarkable inward change in the circulation. In the larval stage, with respiration by gills, the heart and circulation resemble that of the fishes—a single auricle and ventricle and complete purification of the blood. But, as the gills disappear and the lungs devel-

op, and the blood is diverted from the former to the latter, there is a corresponding change in the carrying capacity of the blood-vessels, resulting in the final disappearance of the vessels connected with the gills. Moreover, while the blood was not returned directly from the gills to the heart, it is returned directly from the lungs, and a second auricle is developed. But the aërial respiration of the frog, with its mixed circulation, is more rapid than the aquatic respiration with the perfect circulation of the tadpole.

In the reptiles circulation is essentially the same as in the amphibians; but the ventricle is more or less divided by a partition into two chambers. This membranous partition is perfect only in the crocodile, where we find a right and left ventricle without communication, and the heart structurally like that of a bird or mammal. But the circulation is still the same as in the lower reptiles, for the pure and impure blood are somewhat mingled by a communication between the two arteries near their point of origin.

Although birds in their general organization are closely allied to reptiles, their circulation is similar to that of the mammals. In these

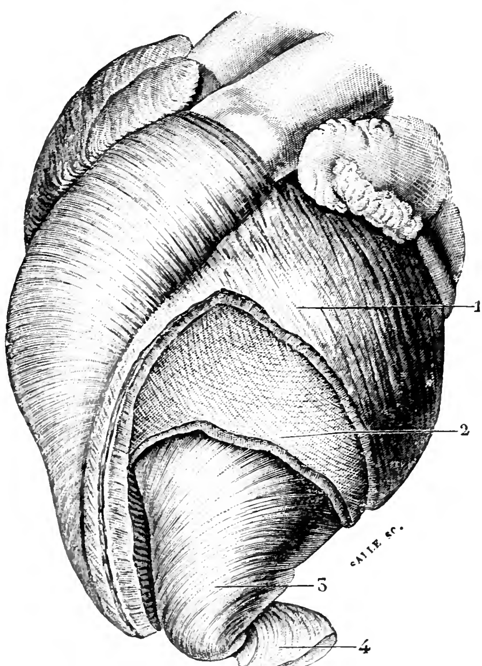


FIG. 5.—MUSCULAR FIBERS OF THE VENTRICLES. 1, superficial fibers, common to both ventricles; 2, fibers of the left ventricle; 3, deep fibers, passing upward toward the base of the heart; 4, fibers penetrating the left ventricle.

two highest classes of the animal kingdom, there are always two auricles and two ventricles, and the right and left sides of the heart are entirely distinct. Functionally these are two hearts: a systemic heart,

forcing pure blood to the body; and a pulmonary, forcing impure blood to the lungs. The pure and impure blood are never mingled, and all the blood has to pass through the lungs and be oxygenated every time it makes the complete circuit. This perfect circulation, with aërial respiration, produces more rapid chemical changes in the blood and tissues, and consequently the higher temperature of the "warm-blooded" animals. In the embryonic stages of the heart, the septum dividing the auricles is slowly formed, and an aperture exists for a time, called the *foramen ovale.* Cases rarely occur of human subjects in which the opening persists. Such persons are physiologically reduced to the condition of a reptile. It is stated that human infants have lived several days with a circulation as mixed as that of a frog.

To economize space and muscular effort, these two hearts are formed of the same circular muscles, and are inclosed by a lubricating membrane called the pericardium. In the dugong, however, the two ventricles are quite separate, showing a structural distinction corresponding with the functional difference.

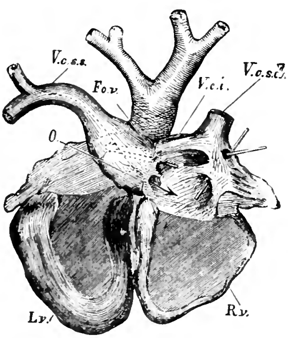


FIG. 6.—DORSAL VIEW OF THE HEART OF THE DUGONG (*Halicore*), ITS CAVITIES BEING LAID OPEN, SHOWING THE SEPARATION OF THE VENTRICLES. *R v*, right ventricle; *L v*, left ventricle.

On account of the structural union, the two hearts contract and dilate in unison, producing the "beating" of the heart. The cause of the first sound in the heart-beat is uncertain, but it occurs at the time of the ventricle contraction. The second sound is produced when the ventricles dilate, by the flapping back of the semilunar valves, those placed at the origin of the arteries to prevent the regurgitation of the blood.

Each half of the heart of birds or mammals is, like the entire heart of the fishes, a double force-pump, with perfection of valves and tubes and surpassing efficiency. The power is enormous. It has been estimated that, while an engine can lift its own weight three thousand feet in an hour, and an active climber can ascend four thousand feet, the human heart performs hourly a labor equal to lifting its own weight twenty thousand feet. Its daily work is also estimated at seventy-five thousand kilogramme-metres. We can otherwise gain an idea of the power of Nature's enginery, by observing what the heart actually performs. The quantity of blood in the human body is at least six quarts. In its course it has to traverse many feet of tubing and two sets of capillaries, and, notwithstanding the friction and loss of power, all the blood completes the circulation in about thirty-two heart-beats. We should further observe that the heart never rests, but is ceaseless from birth to death. Its cessation is death.

The necessity of uninterrupted action of the heart requires that it

should be involuntary, and so its action is placed beyond our control. It is said that an individual once lived who could stop for an instant, at will, the beating of his heart. But, it is also stated in connection, that he died as the result of a too successful attempt.

The flow of blood through the arteries by successive impulses is facilitated by their branching at acute angles. Veins, on the contrary, branch at greater angles, which is compatible with a steady and slower flow. As the veins carry in any given time the same amount of blood as the arteries, while the rate of flow is slower, it follows that their diameter or capacity is greater.

The pressure of the blood-current diminishes from the heart. In the carotid artery of man it is probably equal to the weight of one hundred and fifty to two hundred cubic millimetres of mercury. The pressure in the pulmonary artery is only thirty to forty cubic millimetres.

There is much disagreement among writers regarding the velocity of the blood. In the carotid artery of the horse, it probably flows at the rate of about three hundred millimetres per second; in the dog, at the rate of three hundred to five hundred millimetres. The velocity in the large arteries of man can hardly be over twenty inches per second, but varies greatly at different times. The length of the capillaries is about one half of a millimetre, and the blood passes through them in about one second. In the human retina the corpuscles travel at the rate of ·75 millimetre per second. The small arteries pulsate within one sixth of a second after the main trunks ; but the rate of flow is much slower than the wave-progression.

In vertebrates, the rapidity of the circulation is generally proportionate to the activity of the animal. The pulse of aërial birds is about 150 per minute ; of the cat, 115 ; dog, 95 ; man, 72 ; ox, 35. But this generalization does not hold with the invertebrates. Insects, the most active of all creatures, have a very sluggish and imperfect circulation, for in this class the air is so freely admitted into the body as to obviate the necessity of great movement of the blood.

The human pulse is somewhat more rapid in childhood, and again in old age ; slightly faster in the evening than in the morning, in summer than in winter, and probably increases with geographical altitude. In fever the circulation is very greatly and mysteriously quickened.

All the blood of a man probably completes the round of the circulation in about thirty-two heart-beats, or in less than half a minute. The blood of a horse, it is estimated, completes the circuit in thirty seconds, that of a dog in fifteen, and that of a rabbit in seven seconds.

The velocity of the blood decreases from the ventricles toward the capillaries, and then increases from the capillaries toward the auricles. The velocity being necessarily the reverse of the carrying capacity, or

sectional area. The capillaries have a sectional area several times that of the aorta, the purpose of this being to delay the blood at the time it is brought into most intimate contact with the tissues.

The walls of the capillaries are of extreme tenuity, and easily permeable under the physical action called osmosis. Even the corpuscles can pass outward through the walls.

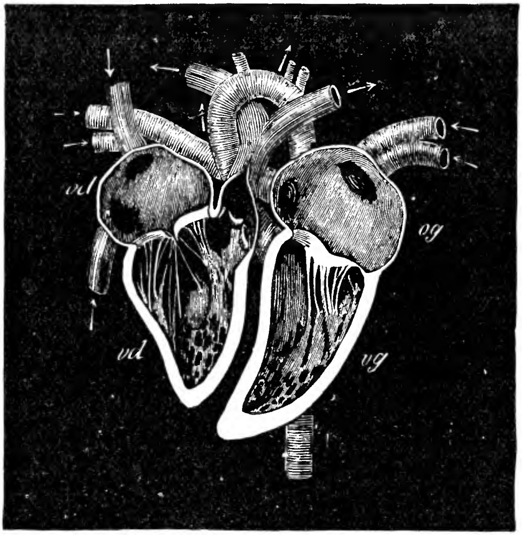


Fig. 7.—Diagram of the Four Cavities of the Human Heart. *o d*, right auricle ; *v d*, right ventricle ; *o g*, left auricle ; *v g*, left ventricle. The arrows indicate the course of the blood.

To what degree the heart is aided by other forces is yet a matter of investigation. Probably there are several forces assisting. The elasticity of the arteries increases their carrying capacity. They are firm, elastic tubes, which expand under the pressure from each heart-contraction, and then by their own elasticity contract and help the onward flow of the blood. In the smaller arteries the flow loses the intermittent character it possesses in the larger arteries, and becomes a steady stream. The elasticity of the arteries serves precisely the same purpose as the air-chamber of any force-pump, that of equalizing the flow, and so increasing the amount delivered. The whole force is derived from the heart: the arteries cause the force to act continuously.

The veins are lax tubes, somewhat larger than the arteries, and capable of holding all the blood of the body. They convey the same amount of blood as the latter, but more slowly. In the larger veins, however, near the auricles, the velocity may be two hundred millimetres per second. They are provided with valves which effectually prevent the blood from flowing backward toward the heart. Any compression, produced by muscular contraction, or otherwise, will therefore assist the forward flow of venous blood. This is one explanation why

exercise hastens the circulation. The movement of the chest in breathing probably aids the pulmonary circulation, the blood, as well as the atmosphere, tending to fill the vacuum during inspiration.

Physical capillary force is not generally regarded as an active force in the circulation. But there is an admitted force in the capillaries, resulting from the attraction of the tissues for the arterial blood, containing the required oxygen and nutriment. "The vital condition of the tissue becomes a factor in the maintenance of the circulation." It is this force, primarily, which adapts the amount of blood to the varying needs of any organ ; the nervous system regulates the supply by varying the caliber of the vessels.

The force in the capillaries, or some other force, carries the blood, after death, from the arteries, where the heart leaves it, into the veins.

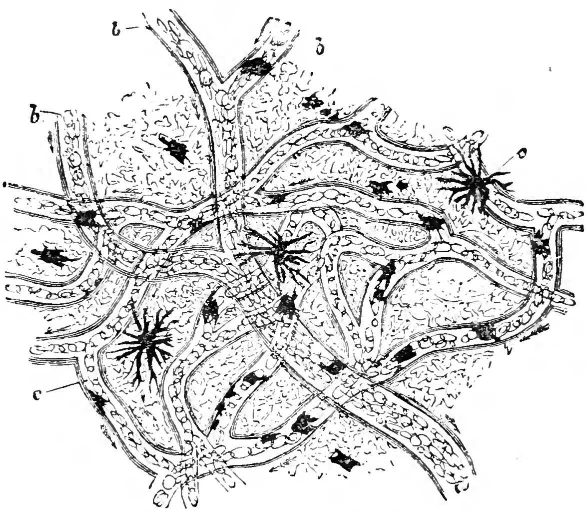


FIG. 8.—CIRCULATION IN THE WEB OF A FROG'S FOOT. The black spots, some of them star-shaped, are pigment, or coloring-matter. *a*, a venous trunk, composed of three principal branches (*b*, *b*, *b*), and covered with a plexus of smaller vessels (*c*, *c*).

Finding the arteries empty after death gave rise to the idea that they conveyed only air ; whence the name. It was this belief which Harvey overthrew in 1620.

In bats the heart is aided by the rhythmic contraction of the veins in the wing. Other accessory hearts of the lower animals have already been mentioned. In some of the lowest creatures, the cause of the circulation may be wholly the movements of the body, as in the jelly-fish and anemone ; or by cilia, as in the sponge, where the sea-water answers to blood.

Under the influence of nerve-force, the walls of the arteries and capillaries are usually somewhat contracted. The withdrawal of nerve stimulus allows the tubes to relax, which consequently permits more blood to pass through, or to accumulate, and perhaps add color to

the skin. This is the physiology of blushing. Congestion is produced by a permanent expansion of the capillaries. We might call blushing a momentary congestion.

In an emergency the arteries are capable of great expansion. They are connected by branches, or loops; and, in case of stoppage of the circulation in a large artery, either by disease or a surgical operation, another will, after a time, perhaps a few hours, expand to a size requisite to carry sufficient blood. This variation in the carrying capacity of the arteries is the important secondary means of adapting the amount of blood to the wants of any part of the body.

In man there is a greater and more direct supply of blood to the right arm, corresponding to the greater use of that limb. But, in birds, equality of supply is necessary for the equality of strength needed in steady flight.

For protection, the arteries are as deep-seated as possible, lying beneath the muscles, and appearing rarely at the surface. At the joints they form loops, so that the circulation may not be stopped by compression of a single trunk. A fine example of adaptation is seen in the arm of the lion, where the main artery, to be protected by the powerful muscles, passes through a perforation in the bone.

ABOUT MEASURES OF LENGTH.

By ROMYN HITCHCOCK.

FEW realize the great practical importance of extreme accuracy in standards of weight and extension, and it is not generally known what degree of accuracy has been attained in the measurement of the standards of length now in use in different countries. The carpenter's foot-rule and the tailor's yard are familiar articles, but, if asked, probably neither the carpenter nor the tailor could tell whether there is any means by which the true length of a foot or a yard can be determined. It is clear, however, that there must be a standard with which the common measures should be made to agree, in order to have the same absolute value. But we may reflect that the constant use of any measure will change its length, and that it will eventually become worn out. We can, then, readily understand the great value of an accepted standard, from which copies can be made, thus preventing any gradual alteration in our measures. Such standards of reference are properly held in the custody of national governments, scientific societies, and institutions.

It is by no means a simple process to compare one measure with another, and to determine the variation between the two. On the contrary, the utmost skill and long experience are required for such

work, as well as the most elaborate and costly apparatus. Allowance must be made for errors that are so small as to be almost inappreciable, but which can not be eliminated until they have been subjected to future investigations of a very delicate nature. Every careful observer will obtain results which are almost marvelously accordant *inter se;* but the results obtained by two observers, with different instruments, will probably not agree. The "personal equation" has not yet been eliminated from work of this kind.

In the comparison of weights and measures, science demands the utmost accuracy, and it would not be possible, even if it were desirable, in an article like this, to more than allude to a few of the steps which have resulted in the final adoption of national and international standards. Professor W. A. Rogers, of Harvard Observatory, has devoted himself to a critical study of measures of length, and to him we are indebted for many observations on the subject, of great scientific importance, and for some very ingenious devices for making accurate comparisons of spaces. He has recently published a valuable contribution to the literature of the subject,* in which the present state of the question of standards of length is discussed with considerable detail.

As the comparisons of measures of length are made with microscopes, the results are affected by the magnification and by the method of illumination employed. The measurements are made so carefully that the standard metal bar upon which the graduations are made must be carefully supported on rollers, mutually connected by a system of levers, so that no flexure can take place, or else a bedplate must be so carefully adjusted in an horizontal plane that no effect of flexure can be detected. Professor Rogers has adopted the latter plan, and he believes that no part of the bedplate of his comparator is more than ·00002 of an inch from the true level.

In constructing a standard, the shape of the bar and the material of which it is composed require careful consideration. In a few cases, standard bars seem to have undergone some molecular change by which their length has been altered. As an example, we may cite this instance: A Russian standard, which was used at one time in geodetic surveys, after it had been transported for a distance of about eight thousand miles, was found to have shortened in length by about one six-thousandth of an inch. This bar was of iron, about seven feet long.

The influence of temperature upon the length of a metal bar is very noticeable, when careful measurements are made. Not long ago, before our knowledge of this subject was as complete as it is now, it was assumed that, if two bars were allowed to remain in a liquid maintained at a certain temperature, they would soon acquire their

* "Proceedings of the American Academy of Arts and Sciences," vol. vii, New Series, p. 273.

true length for that temperature. Is has lately been shown, however, by the experiments of Professor Rogers, that if two steel bars, one of which is nickel-plated, be subjected to a gradual change of temperature, they will acquire their true length after the temperature has been maintained constant for about twelve hours; but, if the change be an abrupt one, it is not safe to compare them until after the lapse of from forty-eight to sixty hours.

Enough has been said to indicate what great precautions must be taken in order to obtain accurate copies of a given standard of length. We may now consider how the standard measures at present in use were originally obtained, and how they are related to each other. We will confine our attention to the measures of France and England, since these possess more interest for us than do the measures of other nations, with which we are less familiar.

It is quite generally supposed that the length of a yard exactly corresponds to the length of a pendulum beating seconds of time, in a vacuum, in the latitude of London, at the sea-level. This, however, is not the fact. The act of Parliament in relation to this matter has been generally misunderstood, for it does not declare the length of the yard to be absolutely that of the pendulum; in truth, these lengths are not the same. Parliament only provided that, in case the original standard should be lost, it could be restored by reference to the unit-pendulum. The standard that was legalized was made by Bird, from Graham's scale, in the year 1760. It was named the "imperial standard yard."

According to experiments conducted at that time, it was found that the relation between the length of the standard imperial yard and that of a seconds-pendulum was in the proportion of thirty-six inches to thirty-nine inches and $\frac{1393}{10000}$ of an inch. On October 16, 1834, both Houses of Parliament were destroyed by fire, and, although the imperial yard was found in the ruins, it had become unfit for use as a standard. The problem of its restoration was then presented, but since the passage of the act of 1824, which declared the relations between the pendulum and the lost standard, it had been found that the data from which the relations were calculated were, in several respects, unreliable. It was finally decided not to attempt the restoration of the lost standard by means of the pendulum, but to work from the various standards which had been compared with it. For this purpose six different scales were found available, among which was the tubular scale belonging to the Royal Astronomical Society; but this scale was not the principal authority from which the new standard was constructed, although it is so asserted in both Appletons' and Johnson's Cyclopædias. The scales actually made use of were two by Shuckburgh, one by Kater, that belonged to the Royal Society, and two bars of the Ordnance Department. The work of renewing the standard was intrusted to Sir Francis Baily, but he died

before completing it, and was succeeded by the Rev. R. Sheepshanks. That gentleman first constructed a bar of brass, which he found to measure 36·00025 inches, in terms of the lost standard. From this the present "imperial standard yard" known as "bronze 19" was made.

Before Sir Francis Baily died, he proposed the use of an alloy for standard measures, which is known as Baily's metal. It is composed of sixteen parts of copper, two and a half parts of tin, and one part of zinc. "Bronze 19" was made of Baily's metal; it is thirty-eight inches long, one inch wide, and one inch deep. The graduations are upon gold plugs that are sunk into the bar. The lines are sharp, and are very well adapted to accurate measurement; they are about $\frac{1}{3000}$ of an inch in width. This standard was legalized by act of Parliament on July 30, 1855. The original standard "bronze 19," or, as it is also called, "No. 1," is kept in the "Strong Room" of Old Palace Yard. Four copies of it are in existence: one is at the Royal Mint, one is in charge of the Royal Society, one is in the new Westminster Palace, and the last is at Greenwich Observatory. Forty other copies were made in Baily's metal, and these have been distributed among different Governments, but only two of them are standard at the same temperature as the original.

From what has been stated, it will be observed that there is no natural unit from which our yard-measure has been derived; it is merely an assumed unit of length which has been declared a legal standard by the British Parliament.

The yard-measure of the United States, with which all measures to be verified are now indirectly compared, is known as "bronze bar No. 11," which was presented to the Government by the British Board of Trade in the year 1856. It is standard at 61·79° Fahr. It does not appear, however, that our Congress has ever sanctioned the use of this standard by any enactment. The only standard yard ever legalized by that body seems to have been a copy of a part of an old scale by Troughton, which had been used by the Treasury Department previously to 1856.

There is now a strong movement in favor of the general adoption of the French system of weights and measures in this country. The efforts that have been made to attain this very desirable result have met with great opposition, but this is steadily giving way before rational argument and sound elementary instruction, so that we may safely predict that our very irrational divisions of feet, inches, pounds, and ounces will eventually be abolished, and that a decimal system will take its place. There is a standard metre bar in the possession of our Government, but it has not been declared a standard by Congress, although it is used for comparisons.

The French metre was originally supposed to be equal to the one ten-millionth part of the quadrant of a meridian of the earth passing through Paris. An arc of a meridian which extends from Dunkirk to

Barcelona, running through Paris, was very carefully measured by Messrs. Méchain and Delambre, and, by comparing their results with measurements that had been made of other arcs, they were able to obtain the length of the meridional quadrant of Paris. Four iron bars were then prepared, and their ends were ground and polished until they were of the required length, to represent one ten-millionth part of the quadrant, or one metre. One of these is now in the possession of the United States, and it is supposed to be the only one in existence. One of the original bars was chosen as the standard of France, and the metre of the French Archives was made directly from it, and at the same time two other similar bars were made, one of which is the metre of the Conservatoire and the other is the metre of the Observatoire. These bars are made of platinum.

In the year 1870 a Commission was formed at Paris, which is known as the "Commission Internationale du Mètre." This Commission, after mature consideration, concluded that the natural unit which had been assumed was far from satisfactory, for reasons which were well set forth in the scientific journals at the time. The Commission therefore declared, as it had full power to do, owing to its international character, that the metre of the Archives should be perpetuated for ever as the true metre. It thus appears that the French unit is no more firmly established, so far as any natural basis is concerned, than is the English yard. It may be of interest to know what relation the accepted standard bears to the length of the natural unit that was first proposed. It has been shown, by the more recent investigations of Clark and Shubert, that the Archives-metre falls short of being true to the natural unit by one fifty-four-hundredth part.

The iridio-platinum alloy, which the Commission has decided to use for standards, is "composed of ninety parts of platinum and ten parts of iridium, with an allowance of two per cent. variation more or less." In 1874 an "International Bureau of Weights and Measures" was established at Paris, to be supported by *pro rata* contributions from the signing powers. This bureau is charged with the care of prototype standards, and with the duty of constructing and verifying copies of them.

The work of preparing the prototypes devolved upon the French section of the Commission, but the International Bureau declined to accept the standards that were submitted, on the ground that the platinum-iridium alloy contained about two per cent. of iron, and was not, therefore, of sufficient purity. The work of the Bureau has been delayed on account of this unfortunate circumstance; but M. Tresca, the secretary of the French section, does not admit the validity of the objections that have been made to the alloy. The buildings of the International Bureau afford great facilities for its work; in one room, where standards of weight are compared, there is a very perfect apparatus for weighing in a vacuum. It is so arranged that the weigh-

ing can be done from a distance of about eight metres (over twenty-five feet) from the balance. In the room where standards of length are compared, there is a comparator which cost about three thousand dollars, and another one is probably completed by this time, which is worth five thousand six hundred dollars.

It seems strange that the precise relation existing between the imperial standard yard and the metre of the Archives is not known. Nevertheless, it is true, for the two measures have never been directly compared. No equation can be assigned to them that is not likely to be erroneous by at least ·005 of an inch; but, in the year 1878, Parliament declared that the legal value of the metre, in inches, should be 39·37076.

It may be thought that so small an error as five one-thousandths of an inch, in a bar more than three feet long, is not worthy of serious consideration; but the fact is, that any error that can be detected by the most refined instrumental means is of great consequence, especially for scientific work. The error mentioned above will appear as a relatively large one, when we state with what accuracy minute measurements may be conducted. Professor Rogers considers that the error in comparing the length of two metre bars need not exceed the one-millionth part of a metre. In terms of an inch this error, expressed in figures, would be ·0000039. In testing the performance of his excellent comparator, he found the value of a centimetre, in terms of an inch, to be ·393707. The generally accepted value is ·393708, which indicates a truly wonderful degree of accuracy in the instrument.

Professor E. W. Morley has made some experiments to determine the probable error in micrometric measurements, and he has found that the errors of a single observer, under the particular conditions described, were very small. With a low-power object-glass, the probable error does not exceed thirty-nine ten-millionths of an inch. With a greater magnifying power he found it to be about thirty millionths of an inch. These errors, inconceivably small as they are, can be made appreciable by means of a microscope.

ARE CEMETERIES UNHEALTHY?

By M. G. ROBINET.

IF the tomb is characteristic of humanity, as Vico has said, the cemetery, M. Pierre Lafitte remarks, is absolutely necessary to all human society. It not only furnishes a more or less hygienic method of disposing of the bodies of those who are no more—it is also a fundamental institution, in the sense that it is a symbol in no way arbi-

trary of human continuity. The cemetery ought, therefore, in every city to be preserved and improved, as something indispensable to the intellectual and moral improvement of the people. It constitutes an interest of the first order, the care of which justifies all necessary efforts and expenditures. With a large part of the public, however, hygienic considerations far outweigh all the moral and social advantages to be derived from the maintenance of cemeteries; and, in justice to the views of this class, it is proper to inquire to what extent the existence of cemeteries, in or near a city like Paris, can be dangerous to the public health.

The injurious effects attributable to cemeteries can be exhibited only through the air, the soil, and the waters. Let us examine each of the three cases.

The air may be contaminated by the disengagement of poisonous gases, or by the propagation of miasms.

The decomposition of bodies in the earth is a real organic combination; its products are quite well known. The principal and most abundant of them is carbonic acid, a substance that is generated by the slow combustion of the carbon contained in all organic matter, vegetable or animal, whether it be a blade of grass, a leaf, wood, manure, or a dead body. It may be disengaged from the soil in cemeteries, and most hygienists have till now considered it one of the principal causes of their insalubrity. This is a mistake. We have on a recent special occasion made an approximate calculation of the maximum quantity of carbonic acid that can be produced in the cemeteries of Paris. The results of these calculations, which are based upon numerous weighings of corpses made in several hospitals and on the most authentic data of the chemical composition of the human body, show that this quantity is infinitely less considerable than has been supposed. The total weight of the bodies consigned each year to the cemeteries in Paris is 1,389,000 kilogrammes (3,472,500 pounds). If all their carbon were transformed (which is not the case) and disengaged as carbonic-acid gas, they would furnish 1,257,000 kilogrammes (3,142,500 pounds) of that gas in five years. Now, according to the calculations of M. Boussingault, we may estimate the quantity of carbonic acid produced in Paris, by the respiration of men and animals and the different processes of combustion, at 18,000,000 kilogrammes (or 45,000,000 pounds) in twenty-four hours. The combustion of illuminating gas alone in Paris (218,813,875 cubic metres) produced last year a quantity of carbonic acid thirty-five hundred times more considerable than all the dead buried in the cemeteries during five years could give at the maximum rate of exhalation. The Grand Opera-House alone gives out every year thirteen times more carbonic acid from its gaslights than could be disengaged from all the cemeteries put together, even if all their carbon were converted into gas.

After examining these figures, and comparing them with the very

precise experiments recently made by MM. Jules Reiset, Muntz, and Aubin, on the proportion of carbonic acid in the atmosphere, which go to show that the proportion of this gas in the air of Paris is no more considerable than in the country, we have a right to affirm that positively no danger to the public health exists from this source.

The truth is, that most of the accidents which happen in burial-places must be attributed only to confined carbonic acid. These accidents are, moreover, much less numerous than is supposed. Different authors do not report more than twelve or fifteen cases, and the theory that cemeteries are centers of infection has been built upon this small basis. Such accidents have been attributed to "pestilential emanations, to certain subtile and deleterious gases, to unhealthy miasms," etc. In reality, the accidents noted have been caused by the carbonic acid which has settled in the pits or vaults by virtue of its superior specific gravity. The same happens much more frequently than in cemeteries, in lime-kilns, marl-pits, some cellars, fermenting vats, everywhere, in short, that carbonic acid is liable to accumulate within a limited space.

The absence of any facts relative to other gases than carbonic acid that might be disengaged in the course of cadaverous decomposition ought to have made those who are so sure of the dangerous character of cemeteries more circumspect; notwithstanding there are no such facts, these persons, besides magnifying the dangerous consequences of the liberation of carbonic acid, speak also of the no less fearful dangers which result from the generation of "certain gases and of certain volatile products." Only two gases have been found to be present to an appreciable extent in the confined air of mortuary vaults, or in the atmosphere immediately surrounding a body in decomposition—as, for instance, within the inclosure of a leaden coffin. These two gases are poisonous when breathed in a certain quantity; they are ammonia and sulphuretted hydrogen, forming, when they combine, sulphohydrate of ammonia. The most delicate reagents disclose no trace of these gases in the free air, nor even in the atmosphere of the cemeteries of Paris, although such tests often, when applied in the same manner, indicate their presence in water-closets, sinks, cellars, and sewers. In the absence of ammonia and sulphuretted hydrogen, we might (though no one has yet done so) imagine the presence of the *ptomaïnes*, those alkaloids of dead bodies recently discovered by Professor Selmi. We anticipate this accusation, by observing that the presence of ptomaïnes in the open air has never been detected. It has been proved that they are not always poisonous; and they exist only in inconsiderable quantities. So far as is known, the ptomaïnes may be simply resultants of the transformation of other principles during extraction, for "they sometimes exhale a perfume like that of certain flowers, as the orange or wild-rose, and of certain aromas"—odors which it is well known are not found among those of cadaverous pu-

trefaction. Moreover, these alkaloids, according to Selmi, are readily decomposed in contact with the air. The ptomaïnes, then, can not enter into account in establishing a noxious character for cemeteries.

Assuredly there are miasms. We do not mean by this term those famous entities by which populations have been struck with terror, but those infinitely small, inferior organisms, the *microbes*, whose existence can not be disputed after the brilliant investigations of contemporary micrographs, especially those of M. Pasteur. We have no disposition to ignore the existence of four or five species of microbes, the destructive effects of which appear to be well established, such as the anthrax-bacteria, the septic vibrion, Obermeyer's spirill, the micrococcus of the hen-cholera, and some other less well-known bacteria. But, without denying that the air may convey infectious germs, and that these may penetrate into the human organism through various channels of absorption, facts which have become almost classical, we still have to examine whether cemeteries, more than other places, give rise to these miasms, these legions of microbes, whose presence in considerable numbers in certain places, notably in hospital-wards, is incontestable.

A number of well-established facts go to prove that the different germs are destroyed by the combustion of corpses in the earth as soon as putrid fermentation begins. We cite the characteristic fact of the disappearance of the carbuncular virus in the bodies of animals that have died of the plague-sore, from the moment the body begins to putrefy (Pasteur, Collin), a fact which is practically recognized by all the horse-killers, who are aware that infected subjects shortly after death cease to be dangerous to them. A more important fact is that the very exact micrographic researches undertaken by M. Miquel in the cemeteries of Paris have certainly shown that there do not exist in them any centers specially productive of germs of cryptogams. This learned physician has ascertained, contrary to the opinion of many authors, that the vapor of water which arises from the soil, from rivers, and from masses in active putrefaction, is always micrographically pure—that is, it contains no microbes; that the gases proceeding from buried matters in decomposition are always free from bacteria; that even the impure air which is caused to pass over putrefied meats, instead of being charged with microbes, becomes fully purified, on the single condition that the infectious and putrid filter is in a condition of humidity comparable to that of the ground at about a foot below the surface. Finally, none of the numerous species which M. Miquel has isolated and inoculated upon living animals has shown itself capable of determining pathological troubles worth mentioning. After this, we may with perfect security put aside those pretended miasmatic emanations, those mysterious effluvia with which certain hygienists have gratuitously frightened an inexperienced public, and which some speculators have turned to good account for themselves.

Regarding the extent to which the soil is affected in consequence of burials, we are in possession of exact and well-established facts. The time required for the earth fully to transform organic matter that may be buried in it varies according to the physical and chemical nature of the soil: in some grounds bodies are, we might say, devoured in a few days; more commonly the time required to transform a corpse is estimated at from five years, as in Paris, to twenty years, as at Geneva, and even more in some places. Authors also differ respecting the time needed for the operation: Gmelin and Wildberg believed that it takes thirty years, while Maret thought that three years are enough.

Legislation based on this point has designated a variety of periods after which burial-grounds may be used over again. At Frankfort, thirty years is the standard; at Leipsic, fifteen years; at Milan and Stuttgart, ten years; at Munich, nine years. Generally, the time necessary for a complete destruction of the body is estimated in France at five years, but this limitation is not at all absolute, and in many cases burial-grounds may be used anew before that time. In the majority of the experiments made by them, Orfila and Lesueur found that bodies were reduced to skeletons at the end of fourteen, fifteen, or eighteen months. After that time, the soil under the vivifying influence of oxygen resumed its original qualities.

On this point, we may assert, contrary to certain affirmations, but in accordance with experiments the importance and value of which are guaranteed by the name of the author, M. Schützenberger, that, so far as the cemeteries of Paris are concerned, no saturation of the soil, either with gases or with solids, exists. The recent experiments of this chemist have resulted, in effect, in showing that the soil in the Parisian cemeteries is still in a sufficiently favorable condition as to its composition to effect the absorption of the gases and the complete transformation of the solid and liquid matters resulting from the putrefaction of the bodies that may be buried in them. The analysis, so far as it refers to gases at least, has given identical results with the analyses of good arable lands. Moreover, there is nothing to prevent the modification of the soil of cemeteries by means of suitable applications for augmenting the intensity and rapidity of its combustible force. Such applications are certainly not beyond the means of modern agricultural chemistry.

No important instance of the contamination of waters has been established against the cemeteries. Cases of an exceptionally unfavorable influence of a mass of decomposing matter on certain waters may occasionally occur, but none such have been established in the soils of Paris, and those which have been described in other places are not conclusive. What, on the contrary, most evidently comes out after a study of the facts is the remarkable purifying power that the earth possesses. It would take too long to give here the proof that water is not infected by cemeteries; we mention only the case of the well in

the cemetery of Montparnasse, the water of which is shown by chemical analysis to be of excellent quality.

With respect to the inferior organisms which some persons believe may be conveyed away by water that has traversed the soil of cemeteries, we may say that M. Pasteur has shown that the waters of springs issuing from the ground even at a slight depth, are so destitute of germs that they can not fertilize the liquids which are most susceptible of change. Such waters, says M. Pasteur, "are at the base of lands which have been traversed incessantly for centuries by streams, the effect of which has been constantly to cause the finest particles of the superposed soils to descend to the springs. The latter, in spite of these favorable conditions for polluting them, remain indefinitely of a perfect purity, a manifest proof that a certain thickness of earth arrests all the finest solid particles."

The wells in Paris being hardly ever used, they ought to be infected by the nitrates which, supposed to be introduced into them, are not drawn from them. It is, however, far from being proved that the cemeteries contribute materially to the excess of nitrates in the well-waters, for the analyses we have made show no sensible difference from those which were made by M. Boussingault twenty years ago. The mean quantity is the same, and our partial results show sometimes a little less, sometimes a little more, saltness than those of M. Boussingault. Now, people have continued to bury, and the ultimate products of decomposition have become more and more soluble; and, if the excess of nitrates that has been observed was due to the cemeteries, it would of necessity have increased.

Besides the precise points which we have reviewed, more general and indeterminate accusations are made against the cemeteries. Such charges are connected with the prejudice, often ill-founded, under the influence of which we *a priori* attribute injurious properties to everything that smells badly. This error arises in part from the repugnant associations which are commonly attached to the substances and places from which bad smells emanate; but, while we admit that effluvia which offend the sense of smell are not agreeable, it is not true that such emanations are generally injurious to the public health.

The facts of this order, which have long served as the foundation of the accusations directed in the name of hygiene against the cemeteries, date from the last century, when chemistry and hygiene were still in the rough. No modern observation enforces them. On the contrary, contemporary scientists, who have studied the effects of animal putrefaction, are almost unanimous in regarding it as innocuous. Such is the opinion of the most authoritative modern authors, Dr. Warens, Bancroft, Andral, Parent-Duchâtelet, and, more especially with reference to cemeteries, Professors Depaul and Bouchardat.

It is hardly necessary to mention that a number of occupations expose those engaged in them to putrid exhalations, without producing

injurious results upon them. Thus, soap-boilers and chandlers are known to enjoy excellent health, and not to be subject to fevers or epidemic affections, notwithstanding they often use fat in a very advanced stage of putrefaction (Tardieu). Tanners and curriers are neither more frequently nor more seriously ill than other men, aside from the occasional carbuncular affections they may acquire by real and direct inoculation, although they are often obliged, especially in summer, to work upon hides that are green with putrefaction. The same may be said for scavengers. The gases which, confined in pits, cause asphyxia, bring no diseases upon the men when a sufficient quantity of atmospheric air is present with them. Grave-diggers, instead of being more subject than other men to febrile, contagious, or epidemic diseases, have always been supposed to enjoy a certain immunity against them. Examples illustrating this principle are not wanting. A long catalogue of them might be cited without any trouble, except to the reader, to whom the reiteration would be tedious.

In conclusion, it may be affirmed that, to the present day, not a single instance of positive noxious infection has been laid to the charge of the cemeteries of Paris. We are in a situation, therefore, to reassure the public on this point, and to deplore with the illustrious Fourcroy "the abuses which certain persons have made of the discoveries in physics and chemistry, taking advantage of them to magnify and multiply complaints against the air of cemeteries and against its effects on the neighboring residences."

Let us say, if we have not courage to support it, that the spectacle of death ought to be hidden from our sight, that in our life of feverish industrialism we have no time to spare for the dead; let us even acknowledge that we have speculative reasons for desiring to remove the burial-grounds from Paris; but let us stop invoking science, let us stop invoking hygiene; let us stop asserting that cemeteries are real centers of infection, that they are susceptible of developing the germs of the gravest maladies; let us stop frightening the ignorant public with sonorous words and phrases. It is easy enough to say and repeat that cemeteries are a source of dangerous emanations, but assertions are not proofs.—*Revue Scientifique.*

INHERITANCE.

By CHARLES DARWIN, F. R. S.

THE tendency in any new character or modification to reappear in the offspring at the same age at which it first appeared in the parents, or in one of the parents, is of so much importance, in reference to the diversified characters proper to the larvæ of many animals at successive ages, that almost any fresh instance is worth putting on

record. I have given many such instances under the term of "inheritance at corresponding ages." No doubt the fact of variations being sometimes inherited at an earlier age than that at which they first appeared—a form of inheritance which has been called by some naturalists "accelerated inheritance"—is almost equally important, for, as was shown in the first edition of the "Origin of Species," all the leading facts of embryology can be explained by these two forms of inheritance, combined with the fact of many variations arising at a somewhat late stage of life. A good instance of inheritance at a corresponding age has lately been communicated to me by Mr. J. P. Bishop, of Perry, Wyoming County, New York. The hair of a gentleman of American birth (whose name I suppress) began to turn gray when he was twenty years old, and in the course of four or five years became perfectly white. He is now seventy-five years old, and retains plenty of hair on his head. His wife had dark hair, which, at the age of seventy, was only sprinkled with gray. They had four children, all daughters, now grown to womanhood. The eldest daughter began to turn gray at about twenty, and her hair at thirty was perfectly white. A second daughter began to be gray at the same age, and her hair is now almost white. The two remaining daughters have not inherited the peculiarity. Two of the maternal aunts of the father of these children "began to turn gray at an early age, so that by middle life their hair was white." Hence the gentleman in question spoke of the change of color of his own hair as "a family peculiarity."

Mr. Bishop has also given me a case of inheritance of another kind, namely, of a peculiarity which arose, as it appears, from an injury, accompanied by a diseased state of the part. This latter fact seems to be an important element in all such cases, as I have elsewhere endeavored to show. A gentleman, when a boy, had the skin of both thumbs badly cracked from exposure to cold, combined with some skin-disease. His thumbs swelled greatly, and remained in this state for a long time. When they healed they were misshapen, and the nails ever afterward were singularly narrow, short, and thick. This gentleman had four children, of whom the eldest, Sarah, had both her thumbs and nails like her father's; the third child, also a daughter, had one thumb similarly deformed. The two other children, a boy and girl, were normal. The daughter Sarah had four children, of whom the eldest and the third, both daughters, had their two thumbs deformed; the other two children, a boy and girl, were normal. The great-grandchildren of this gentleman were all normal. Mr. Bishop believes that the old gentleman was correct in attributing the state of his thumbs to cold aided by skin-disease, as he positively asserted that his thumbs were not originally misshapen, and there was no record of any previous inherited tendency of the kind in his family. He had six brothers and sisters, who lived to have families, some of them very large families, and in none was there any trace of deformity in their thumbs.

Several more or less closely analogous cases have been recorded; but until within a recent period every one naturally felt much doubt whether the effects of a mutilation or injury were ever really inherited, as accidental coincidences would almost certainly occasionally occur. The subject, however, now wears a totally different aspect, since Dr. Brown-Séquard's famous experiments proving that Guinea-pigs of the next generation were affected by operations on certain nerves. Dr. Eugène Dupuy, of San Francisco, California, has likewise found, as he informs me, that with these animals "lesions of nerve-trunks are almost invariably transmitted." For instance, "the effects of sections of the cervical sympathetic on the eyes are reproduced in the young, also epilepsy (as described by my eminent friend and master Dr. Brown-Séquard) when induced by lesions of the sciatic nerve." Dr. Dupuy has communicated to me a still more remarkable case of the transmitted effects on the brain from an injury to a nerve; but I do not feel at liberty to give this case, as Dr. Dupuy intends to pursue his researches, and will, as I hope, publish the results.—*Nature.*

INCREASE AND MOVEMENT OF THE COLORED POPULATION.

By J. STAHL PATTERSON.

I. INCREASE.

THE problem of races in the United States is one of growing interest and of great practical moment; that of the colored race, especially at the present time, is full of significance in its social and political aspects. It is proposed in a couple of articles to inquire briefly into the phenomena of increase and movement of the colored population in the light of the most recent observations and statistics which bear upon the subject. The first table we shall consult is that which gives the increase of the white and of the colored population for each decade from 1790 to 1880:

	Year.	White.	Colored.	White gain, per cent.	Colored gain, per cent.	
1st census.	1790	3,172,006	757,208	....	....	
2d "	1800	4,306,446	1,002,037	35·8	32·3	1st decade.
3d "	1810	5,862,073	1,377,808	36·0	37·5	2d "
4th "	1820	7,862,166	1,771,656	34·1	28·6	3d "
5th "	1830	10,537,378	2,328,642	34·0	31·5	4th "
6th "	1840	14,195,805	2,873,648	34·7	23·4	5th "
7th "	1850	19,553,068	3,638,808	37·7	26·6	6th "
8th "	1860	26,922,537	4,441,830	37·7	22·1	7th "
9th "	1870	33,589,377	4,880,009	24·8	9·9	8th "
10th "	1880	43,402,408	6,577,497	29·2	34·8	9th "

It will be seen that the ratio of increase in the colored population had fallen off somewhat before emancipation, although the proportion of fugitives was less from 1850 to 1860 than from 1840 to 1850. By the annexation of Texas, 59,000 colored were added to the census of 1850. Florida was first counted in 1830, with 16,000 colored. Louisiana was purchased in 1803, adding about 30,000 colored to the census of 1810. The slave-trade closed in 1808.

The ratio of increase in the white population was less disturbed by the acquisitions of territory and people. Immigration is the very large factor which here swells the ratio of increase, and this more in later decades than in the earlier ones. During the first decade (1790–1800) the number of immigrants was about 43,000; during the second, 60,000; during the third, 98,000; during the fourth, 150,000; during the fifth, 600,000; during the sixth, 1,700,000; during the seventh, 2,500,000; during the eighth, 2,400,000; and, during the ninth, 2,800,000. It should be kept in mind that, in 1870, there were over 10,000,000 whites in the United States whose mothers were of foreign birth, being 30 per cent. of the entire white population. The tide of immigration received a check during the war (1861–'65), and also during the period of commercial depression, 1874–'79. The war, by checking immigration, marriage, and the fruitfulness of marriage, and by the outright destruction of human life, greatly reduced the percentage of increase during the eighth decade. The check which the hard times gave to immigration reduced the percentage of increase for the ninth decade below the figure it would otherwise have reached. But, after making all allowances for the advantages which immigration gives to the white population, it is probable that from 1810 to 1860 the whites multiplied somewhat more rapidly than the colored people.

The ratio of increase of the colored population, though declining, was quite uniform till the decade 1860–'70. Two classes of influences were then vigorously at work to reduce the ratio—a war which largely concerned the colored people, and the transition from the servile to the free condition. The whole decade was an unsettled period, with every influence against the rapid multiplication of the freed race. The rate of increase for that decade was a little less than 10 per cent.—less than half what it had been the previous decade. The percentage of increase for the decade 1870–'80 is quite surprising. As it has taken place under freedom, it contravenes all the prejudices and upsets most of the philosophies. One would naturally have supposed, from the reputed bad treatment and destruction of freedmen in the South and the preordained tendency of an inferior people to decline in presence of a superior, that the colored race would be dying out, instead of increasing at the marvelous rate of 34 per cent. in ten years.

Previous to emancipation, it was a current opinion, not only among slaveholders but among others, that slavery was conservative of the

colored race, owing to the interest of masters. It was expected that, with freedom, the colored people would begin to die out like the Indians. This was based on the general doctrine that, when a superior and inferior race occupy the same territory, in free competition, the inferior will go into a decline. That this was a total misconception of the subject, on theoretical principles, it would not now be difficult to show ; and, that it was practically wide of the mark, the late census is abundantly sufficient to prove. Still, in the facts known previous to this census, there was much in favor of such a view. In the decades preceding emancipation, the ratio of increase of the free colored was only about half that of the slaves.

Mr. Kennedy, Superintendent of the Census of 1860, believed that freedom was unfavorable to the multiplication of the colored people. He says, "Leaving the issue of the present civil war for time to determine, it should be observed, if large numbers of slaves shall be hereafter emancipated, so many will be transferred from a faster to a slower rate of increase." He held that "the white race is no more favorable to the progress of the African race in its midst than it has been to the perpetuity of the Indians on its borders." He was of opinion that the "developments of the census, to a good degree, explain the slow progress of the free colored population in the Northern States, and indicate, with unerring certainty, the gradual extinction of that people the more rapidly as, whether free or slave, they become diffused among the dominant race."

If these were the views which appeared to be warranted by the showing of the eighth and previous censuses, they were certainly not contravened by anything in the ninth census (1870), but apparently more than confirmed ; and there was much to encourage the prevailing notion that after emancipation the colored population would increase less rapidly than before. Up to the very taking of the last census this opinion had taken such hold as to enter as a factor into political calculations. It was expected by leaders of both the great parties that under the new census the South would lose relatively in Congressional representation.

Perhaps the writer may be permitted to state that, about the middle of the last decade (1875–'76), he made a leisurely trip through the South, one object of which was to study this subject. He found no physician in the South, whether native or Northern, but believed that the colored race was in a decline and slowly undergoing the process of extinction. It was believed—no doubt the result of a dominating idea which preoccupied the mind—that births were fewer and deaths more frequent than formerly under slavery. According to the census of 1870, the colored people died off more rapidly than the white, as well in the South as in the North. The report of deaths, though obviously imperfect, shows that this greater mortality of the colored takes place among the children. It was found that the cemetery

records of sextons in the larger towns of the South confirmed this showing of the census. But, for all this, all through the South, there were such swarms of little colored people about the huts, that the writer was constrained to withhold his assent to the notion that the race was dying out, stating at the time that, "notwithstanding the showing of these statistics, we suspect that the greater number of births compensate for the greater number of deaths, and that the next census returns will show little if any diminution of the relative proportion of the negro to the native white population."

It must be mentioned, however, that the showing of the last two censuses is not altogether free from suspicion. It has been thought that either the census of last June made too many colored people, or that of 1870 made too few. Where most in doubt, the last census has been retaken with care, in parts of South Carolina three times in all, and the work first done thus verified as correct. The probability is, that the census of 1880 is as accurate as such work can well be done. The census of 1870 is not so well authenticated, but it was thought at the time to be correct. Whether it failed to enumerate all the colored is a matter of speculation only, which can never be satisfactorily determined. It is now believed in the Census-Office at Washington that all the colored were not enumerated in 1870. Possibly this is the case to a certain extent, but it is just possible that it may not be necessary to suppose error in either of the censuses to account for the great increase during the last decade. The census of 1870 shows that reproduction had been greatly checked in this as in other classes; and it shows this even if we allow a large margin for error. But this state of things rapidly changed, and the colored people of the South began life anew about the year 1870. They were no longer disturbed by the war, nor seriously molested by the lawless elements of the South. They had become comparatively well settled in their new status of freedom. They found something to do, and something that paid, as the successive great cotton-crops of the South show; and that hopefulness in life which followed the period of anxiety contributed an unusual stimulus to reproduction. With more settled habits came marriage and rapidly increasing families. The census of 1870 shows that the proportion of children under ten years of age was nearly one per cent. less among the colored than among the native whites. This is due, no doubt, to the American-born children of immigrants being counted as natives; but it is probable that the census report of 1880 will reverse this showing. Comparison can not be made in earlier reports because the native and foreign whites were not kept distinct.

The following is from an intelligent correspondent of Floyd County, Georgia, to the "Country Gentleman" of July 15, 1880—Mr. J. H. Dent: "So far as I have heard from the census enumerators, they report that the increase of negroes by birth is remarkable. The enumerator of this district told me that in three families he found thirty

living children, which surpasses anything of the kind among the whites. I have three negro tenants on my farm, and among them they have fourteen children; and for health, flesh, and vigor, I would compare them with any children at the North or elsewhere." It is probable that the advantage of the colored, in the matter of numbers, comes, not from unusual conservation of the living, but from early marriages under ordinary circumstances, and the rapidity with which children are born in the same family, and also, as the census reports show, from the greater tenacity of life from middle age onward. For these reasons mortality might be absolutely greater among the colored, and they still far outstrip the whites in the multiplication of numbers. But there is nothing in the form of positive evidence to show that, in the rural districts of the South, mortality is any greater among colored than among white children.

The colored increase of the last decade, as shown by the census, does not so far transcend the increase of the early decades of the century as to render it at all incredible; and yet, such are the conditions under which this has taken place, that it is no doubt to a certain extent exceptional, and will not be repeated in the future. It is quite safe to predict that the next decade will not show so large a percentage of increase as the last. No doubt the forthcoming "Census Report" will show a greater proportion than usual of colored children in the South from one to ten or twelve years of age. Reproduction will cease in a considerable percentage of these families before the close of the current decade; and, of those born during the last decade, not a very large proportion will marry before the beginning of the next decade. If this view has truth in it, and there should be no disturbing conditions, the rate of increase among the colored in the South will be greater from 1890 to 1900 than from 1880 to 1890, but not so great as from 1870 to 1880 (theory of Reichenbach; "Report of the Eighth Census," Introduction, viii). But, however this may be, no amount of question concerning the last two censuses, the ninth and tenth, can so far invalidate them, but they show the high probability that both freedom and diffusion in peace are favorable, rather than otherwise, to the multiplication of the colored race. This is so, even allowing a good margin for error in the census of 1870. So far as the census of 1880 covers the ground, it does not afford merely the evidence of negation; it is positive, and not likely ever to be shaken.

The aggregate white population of the sixteen Southern States and the District of Columbia was 9,466,355 in 1870, and 12,577,215 in 1880, the percentage of increase during the decade being 32·9. The aggregate white population of the twenty-two Northern States in 1870 was 23,864,272, and in 1880, 30,257,557, the percentage of increase being 26·8. Then we have for the last decade, increase of whites in the North, 26·8; increase of whites in the South, 32·9; and increase of colored in the United States, 34·8 per cent. It should be observed that

the colored people have not so far surpassed the whites of the South in ratio of gain as to give any considerable encouragement to the suspicion of incorrectness in the showing of the census reports. It is as true that the Southern white population has gained slightly from foreign immigration during the decade, but it is also true, as going partly to offset this, that the colored population of the United States has gained slightly from the intermarriage of white women with colored men.

The foreign population in the South is very small compared with that in the North. The foreign-born population in Missouri is (1880) but $10\frac{3}{4}$ per cent. of the native population of the State; in Maryland, $9\frac{3}{4}$; in Texas, $7\frac{3}{4}$; in Louisiana, 6; while in Mississippi, Alabama, and South Carolina, it is about three fourths of one per cent.; in Georgia, two thirds of one per cent., and in North Carolina but one fourth of one per cent. On the contrary, the foreign-born population bears a large proportion to the native in the Northern States. In Nevada it is 70 per cent.; in Minnesota, 52; in California, 51; in Wisconsin, $44\frac{1}{2}$; in Rhode Island, 39; in Massachusetts, 33; in New York, $31\frac{1}{4}$; in Michigan, 31; in Nebraska, 27; in Connecticut, $26\frac{1}{3}$; in Colorado, $25\frac{1}{2}$; in Illinois, $23\frac{1}{2}$; and so on down to Indiana, the lowest, $7\frac{3}{4}$. The aggregate of foreign-born in the Northern States is 5,854,000, while in the Southern States it is only 658,000: that is, 1,011 foreigners out of 10,000 (or a little more than one out of ten) have up to the present time settled in the South. In a comparison of the white gain South and the white gain North during the last decade, the disadvantage which the former has in this element of immigration is without compensation, inasmuch as the migration from South to North is probably about equal to that from North to South, and is comparatively small at any rate. Yet the white gain South was 32·9 per cent., and North but 26·8 per cent. What, then, would be the figures after making proper allowance for the numerical effects of immigration on the population of the two sections? Only approximate results can be had.

The arrival of foreigners during the last decade is counted at 2,813,000. Deducting from this aggregate 60,000 Asiatics as non-prolific, and also other foreigners in the Territories about 65,000 more, there would remain 2,688,000 as the number belonging to the States. But these were not all counted in the census. They were here during an average of nearly five and a half years (the heaviest arrivals having taken place during the earlier years of the decade), and allowance must be made for deaths during this peried. Few children or old persons emigrate. Most are in the prime of life, and the proportion of deaths would probably be allowed for at $12\frac{1}{2}$ per cent. Making this reduction, there would remain 2,352,000 immigrants which were added to the population of the States during the last decade and counted in the census.

But this result may be reached by a different route—by adding the

actual gain in our foreign white population during the decade to the loss of the foreign white population which was here at the beginning of the decade. There were 979,000 more white foreigners in the States in 1880 than in 1870. According to the census of 1870, there were 5,438,000 white foreigners in the States. At 25¼ per cent. for the mortality of this class in ten years, it lost 1,373,000 during the decade. Adding this to the actual gain of foreign white population, 979,000, we get the number of immigrants during the decade, which were still surviving and counted in the census of 1880. The result is 2,352,000 —the same as by the other process. The error in this result must be comparatively inconsiderable.

Then, in order to ascertain the gain of Northern whites and of Southern whites respectively, the numerical disturbance of this foreign element must be got rid of by deducting it from the census figures of 1880; and, to this end, we must know what part of it belongs to the Northern and what to the Southern States. The South during the last decade did not receive its average quota of foreigners. In nine of the Southern States there was a falling off of foreign population amounting to 29,700. Missouri alone lost 11,000. In the other eight there was a gain of 66,000. Texas alone gained 50,000; so that, but for Texas, there would have been a loss of foreign population in the South during the decade. The foreign gain in the South, deducting Chinese, was 35,000; in the North, 944,000. Adding to the first of these numbers the foreign loss in the Southern States during the decade, 157,000, we have 192,000 foreign whites who settled in the South during the decade, and were counted in 1880. By a like process, we find the corresponding number for the Northern States to be 2,160,000. Being enabled thus to eliminate the immigration of the decade, we find the percentage of gain in the white population of the Southern States to be 30·8, and of the Northern States 17·7.

But this calculation does not bring out the relative increase of the native whites North and the native whites South. It includes all the children born of foreign parents who came to this country after the decade commenced; and this is a very considerable item. Of the foreign-born in this country, 23 per cent. are females between the ages of twenty and forty years. Of actual immigrants, it was formerly somewhat less, as it is now probably somewhat more than this. As the immigrants of the decade were here during an average of nearly five and a half years, it would be safe to reckon one living child to each immigrant female between the ages of twenty and forty, deduction having already been made for the mortality of immigrants during the decade. Making this further correction, the ratio of increase for the Northern whites would be 15·7, and for the Southern whites 30·4.

Still we have not reached the relative increase of the native whites North and South. Allowance should be made for the excess of pro-

lificacy of foreign-born mothers who came previous to the beginning of the decade. The foreigners among us have larger families than the natives of the North generally. So large a proportion of immigrants come in the prime of life, that, though the males predominate, foreigners have a larger percentage of increase than natives, even if their families were not larger. While the proportion of foreign-born white females from twenty to forty years of age was (in 1870) 23 per cent. of the entire foreign-born population, the proportion of native white females of corresponding age was not quite 13·8 per cent. of the native white population; but, of course, this great disparity is due in part to the fact that the American-born children of foreigners are counted, not with the foreigners, but with the natives. It is a fact little thought of, that the number of foreign-born white females from twenty to forty years of age is nearly one fourth of all the white females of that age in the United States. In 1870 the number of native white females of this age in the whole country was 3,867,617, and of the foreign 1,260,965, the latter being 24·6 per cent. of the whole. How is it for the Northern States alone?

It is deducible, from the report of 1870, that the foreign-born females in the North, between the ages of twenty and forty years, numbered 1,119,000, while the native-born white females of like age in the same States numbered 2,532,000, the foreign being 30·6 per cent. of the whole. A similar calculation shows that in the South the proportion of foreign-born in the period of motherhood was but 9·6 per cent. Granted an excess of prolificacy in our foreign families over the native, the advantage thereof to the rate of increase accrues wholly to the North. It is not probable that foreigners in this country are any more prolific than, or, indeed, quite as prolific as, the native Southern whites.

On the admission of greater prolificacy in immigrants generally than in Northern natives, the points to be met are so numerous that any arithmetical statement of them would be rather complicated and tedious. We let that pass with the statement of an assured belief that, if proper allowance were made for this element of the problem, the ratio of increase in the native white population of the North would be shown to be very little, if any, above 12 per cent. But we omit this. The comparative rate of increase may then be recapitulated as follows: Native whites North, 15·7 per cent.; whites South, 30·4 per cent.; colored in the United States (allowing 1·5 per cent. for error in census of 1870), 33·3 per cent.

I am aware that the division-line assumed in this statement between the North and South is quite arbitrary, and that where the border States meet there is comparatively little divergence in the characteristics referred to; but some such line had to be assumed to bring out the lesson of this study, and that which has been used probably involves as little disturbance of results as any.

In a comparison of the white and colored increase, the side of color has no offset equivalent to the advantage of immigration for the other side. The only thing in the form of such offset is marrying across the color-line, already referred to. When a white woman marries a colored man, she virtually migrates as a wife and mother, and her children and descendants for ever after count on the colored side. This is taking place to a certain extent—to a very limited extent, it is true; but, as small a matter statistically as it appears to be, the census should put it on record for comparison hereafter. Native children of foreign parentage are designated, and colored children of white mothers should also be designated. The prejudice is at present very strong against such unions; but that prejudice may gradually weaken, and cases of the kind may multiply. This tendency is worthy of note for its significance on the future psychology of the American people. If to the rapid multiplication of the colored population is to be added an accession through white motherhood, the increase of the colored over the white must be accelerated, unless prevented by counteracting influences not at present in existence. And, when in this connection we contemplate the increasingly slow multiplication of the people of highest civilization in our country, the prospect for the future is not an optimistic one.

Very great subjects can only be touched upon, not treated, here. Why is it that the native whites of the North are multiplying so much more slowly, not only than the colored, but even than the Southern whites? Simply because of the possession of greater wealth and culture. It was different early in the century, when the descendants of the Puritans and Dutch stood on a "lower" grade in the struggle of life. Families were larger then. The possession of wealth and education is a surer check on population than the famous "positive checks" of Malthus—"wars, plagues, and famine." They are surer and greater, because they act without intermission. I do not shrink from stating the fact, unpleasant as it may be. I am aware that Knox, Clibborne, Schade, Kapp, and others, refer the slow increase of American natives—they do not discriminate between Northern and Southern—to the effects on the European stock of an uncongenial climate. This is an *a priori* fancy which is entitled to no particular consideration, since it is as wholly without support as that other *a priori* fancy, that the descendants of Europeans in this country are gradually turning into a sort of red Indians.

There is, perhaps, no law of human history better assured than this: that, with high civilization and the long enjoyment of wealth, culture, and the luxury and dissipation which are sure to accompany them, population increases more slowly, in time to become stationary, and at last decline and succumb to younger and more vigorous peoples, who have been hardened in the conflicts of poverty and rough fare. Roscher, the German economist, states this profound truth:

"As a rule, the influences which have accelerated a nation's progress and brought it to the apogee of its social existence end in precipitating its ruin by their further action. Every direction which humanity takes has almost always something of evil in it—is limited in its very nature, and can not stand its extreme consequences. All earthly existence bears in itself, from the first, the germs of its decay." It would not be difficult to point to the springs of human action which must render this necessary, except on the presumption of a revolution in human nature itself, an event not likely to occur.

It is not always the highest that prevail, especially in the conflicts of industry. It is the plodding, the hardy—those who have few wants and can do with little. This is well understood by the industrial classes who have come into conflict with the Chinese in this country and in Australia. And it is plain that a hardy race with moderate wants, which increases twice as fast as a higher race in the same territory, will contribute more and more to the psychological and social status of the whole people. There is nothing surer than that the high-toned Yankee is losing in his relative weight of numbers in this country, and it is equally sure that he will lose more and more, and eventually be absorbed. The German, the Celt, the Southerner, the colored, are all gaining upon him. Some patriotic people deplore the incoming and rapid multiplication of white foreigners in the North; and yet it is this very accession of Caucasian strength that affords the best ground of hope for the psychological elevation of the great American type or types which are yet to take definite form. If only Yankees were contending with the colored for supremacy, it would go far worse with the whites than it now does in the race of numbers. Allowing the increase of the colored to be $33\frac{1}{3}$ per cent. in ten years, they would double four times in less than a century; that is, the census of 1980 would show their numbers to have increased from 6,577,000 to 117,000,000! Taking the increase of the Northern whites to be 15·7, as it is shown to be for the last decade, after eliminating the obvious augmentation due to immigration, their numbers would only double while the colored quadrupled; and the census of 1980 would show that the native whites of the North had increased from 24,403,000 to 105,000,000. That is, the colored race of the United States would then outnumber the descendants of the present native Northern whites by 12,000,000. It is, of course, not to be expected that these ratios of increase would be maintained for that period: both would fall, and both fall, perhaps, in about the same proportion; and this will probably take place, notwithstanding the accession of white mothers to the colored stock and the infusion of foreign blood into the veins of native whites. If these and the colored were the only contestants on American soil, the despised race would make comparatively short work of it, and come to be the prevailing people. As it is, however, with rapid increase of whites at the South, and white immigrants pouring into the country,

the problem is a very different one. But it is still true that at last, at however remote a period, the industrious, hardy, plodding, persistent, breeding race is that which will push its way into predominance. What race will be our Macedonian, our barbarian, or our Turk, can not be divined. It may still be in embryo. The conflict of races is now less on the bloody fields of battle than on the peaceful fields of industry, and other than martial traits of character may hereafter determine who shall be the victors. Formerly the conquerors came from without; hereafter they may spring up within.

In the world's history peoples have risen, flourished, and declined. How or even where they came into existence is not always known; but this we do know, that they came into prominence only by complying with the conditions of ethnical consequence. They were hardy, aggressive, and prolific. And there is this paradox, that the greater they became the surer were they to perish. Greek and Roman belong to the irrevocable past; and many who helped supplant them have yielded in turn to others. The Vandals came like a vision into history and then disappeared. The Thracians, a numerous people in the Eastern Empire during the first century, have long since become extinct. The Vallacians, from small beginnings in the eleventh century, forced their way into history and in two or three centuries passed out of sight. The Ottoman Turks, a small nomadic tribe of Mesopotamia—temperate, hardy, warlike, pushing—rapidly grew into a great historical people, and made a place for themselves where Christians and Greeks once held sway; but they have long since entered on the period of their decline, and eventually some more vigorous people will take their place. If we could know the origin of the vast Teuton family, we should, no doubt, be astonished at its then small promise of future greatness. The Slav is pushing his way into consequence, and we can not appoint the limit of his capabilities. It sometimes takes an obscure race but a little while to rise. This we may study even in our own times. What we know as the Celtic Irish were, only two hundred years ago, less than one million strong; now they number many millions and are increasing with great rapidity. They are not afraid of hardships, and their vices are not of the effeminate kinds which undermine the constitution. They are finding homes in many lands, and who can forecast their destiny? We have a still more recent instance in the colored people of the United States. Eighty years ago they numbered only 1,002,000, but with all their drawbacks they are now 6,577,000. With a like increase for the next eighty years, they would be 43,000,000 strong. Even less do we know of what is in store for this race than for almost any other. The situation is unique, and there is little clear history to guide us; while it is far less likely than any of the white varieties to disappear in the universal blending of races on American soil.

PROGRESS OF HIGHER SCIENCE-TEACHING.

By W. H. STONE,

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IT is doubtful whether the generality of well-educated men fully appreciate the great, the radical, and the almost revolutionary change which has in the past thirty or forty years come over the scope and spirit of English liberal education. Indeed, it can hardly be termed a change; but might be more correctly designated as a substitution of one branch of human knowledge for another. For, whereas, in the first forty years of the present century, the dead languages, especially Latin and Greek, history, logic, and metaphysics, fairly held their own against the computative sciences of mathematics, mechanics, physics, and chemistry, and the systematic or classificatory subjects of botany, geology, and zoölogy as topics of teaching and examination, they seem at the end of the second forty to have been all but superseded. No doubt in the main the revolution, great as it undoubtedly is, has proved salutary. Englishmen, with their characteristic tenacity of existing forms, had retained all but unchanged in their large public schools and in the older universities a form of intellectual culture which really originated in the middle ages, or at the latest with the restoration of learning. This is no mere figure of speech. The writer of the present remarks took his first childish lessons, after mastering the rudimentary arts of reading and writing, from "The Boke of Roger Ascham," and received his first rewards for saying, parrot-like by rote, the ancient farragos now only known by their initial words—"*Propria quæ maribus*," "*Quæ genus*," and "*As in præsenti*." Of the present generation, not one in a thousand has ever even heard of these mediæval *aide-mémoires*, or of the somewhat more useful scholastic scheme of syllogisms, beginning with the cabalistic formula, "Barbara Celarent." Later on, he and his companions were expected weekly to manufacture, *nolentes volentes*, a certain quantity of poetry! —God save the mark!—in the Latin and Greek tongues. He can well remember his father's remonstrance on finding him working at "that nasty chemistry, when you have not done your Latin verses." Perhaps the most singular travesty of teaching was the inculcation of that laboriously useless heap of conflicting rules termed the "Greek accents." It was well known to every scholar that they were non-existent in classical times; that they were probably prosodiacal; that they sprang up about the time when Greek was going out of use as a spoken language; and that, except in very few instances, they now served no purpose whatever. In spite of this, they were steadily and perseveringly thrust down the throats of schoolboys, insomuch that

ignorance of the hideous pedantry of a mediæval grammarian might involve the pain and humiliation of corporal punishment.

That all, or most, of this has been swept away is ground for unmixed satisfaction. But it does not absolutely follow that what is being substituted for it is beyond comment or improvement. There may be errors and pedantries developing in the new as in the older system. Nor are they difficult to point out.

The teaching of science has tended to give an impulse to the computative, to the disadvantage of the judicial and appreciative functions of students' minds. Indeed, the computative faculty, so highly developed at times in men not otherwise liberally educated, is not the widest in intellectual scope, nor the fittest preparation for some branches of life-work. Men in after-life are called upon to use their imaginative powers, to sift evidence, and to weigh symptoms, as well as to solve problems. They may adopt artistic or literary pursuits, they may choose the professions of law or of medicine. In all these, the attempt to reduce the subject-matter laid before them to the strict conditions of an equation or a ratio, so far from being a fruitful mental effort, may absolutely prove a hindrance. There is a common type of mind which fails to see a proof which is not of the character of demonstration, and which, in its absence, neglects to use the faculty of judgment and decision so necessary in the common affairs of business.

The computing school, and especially those who teach its physical branches, very correctly and consistently insist upon the solving of problems as a test of thorough knowledge. Mr. Day, whose work appears to be mainly performed "in the laboratory of King's College, under the direction of Professor Adams," in an excellent collection of questions upon electrical measurement, says, "It is now universally admitted that numerical exercises are necessary in the study of the experimental sciences, both as giving practice in the application of the various theories, and as affording tests of ability to comprehend as well as to apply that which has been learned."

It must be remembered, however, that, even among advanced and professed mathematicians, the faculty of solving problems is very unequally distributed—a fact which is openly recognized at the great mathematical University of Cambridge. The problems themselves are often open to comment, as partaking of the nature of enigmas, or riddles, rather than as fair tests of knowledge. Like riddles, moreover, they exercise a kind of fascination on their concocters, and are very liable to figure in papers of questions. The writer, for instance, has seen in a paper on physics a question which involved an indeterminate equation, and of which the solutions were infinite in number. Surely this should have been relegated to its kindred algebra. But an instance which has occurred within the present year is so exceptional as to deserve quotation. It was a pass, not an honors paper,

set for matriculation—the primary and initial step of the whole university career; a gate to further knowledge, which should be prudently left as wide open as is consistent with a reasonably high standard. The paper consisted in all of sixteen questions, and is therefore too long for quotation in full. Of these, says the heading—

"*Not more than eight questions are to be answered, of which at least two must be selected from Section A.*

A.

"1. State your reason for regarding a pound as a unit of mass and not of force. What is the most convenient unit of force when a foot, a pound, and a second are units of length, mass, and time, respectively?

"2. State the conditions necessary for the equilibrium of a body free to move in one plane. To what do these conditions reduce when one point in the body is fixed?

"3. A solid right circular cone of homogeneous iron is 64 inches in height, and its mass is 8,192 pounds. The cone is cut by a plane perpendicular to the axis, so that the mass of the small cone removed is 686 pounds. Find the height of the center of gravity of the truncated portion remaining, above the base of the cone.

"4. A heavy body starting from rest slides down a smooth plane inclined 30° to the horizon. How many seconds will it occupy in sliding 240 feet down the plane, and what will be its velocity after traversing this distance? [$g = 32.$]

"5. What is the 'kinetic energy' of a moving mechanical system? A shot of 1,000 pounds moving at 1,600 feet per second strikes a fixed target. How far will the shot penetrate the target exerting upon it an average pressure equal to the weight of 12,000 tons?"

If it be borne in mind that judgment on the five momentous mathematical generalizations (for they are hardly within the pale of physics proper) was demanded of boys averaging sixteen or seventeen years of age, fresh from school, it will be evident that the race of schoolmen and of De Morgan's "Conundrum"-makers is not yet extinct, and that the current rumor of the award having been returned to the examiners for mitigation may have some foundation in truth.

It is interesting to note how this radical change in the scope and subjects of education has reacted on our older and on the more recently founded universities. Far in the van stands that of Cambridge. Here, from the traditional character of the instruction given, little modification was required to bring modern requirements into harmony with the older teaching. Ever since the appointment of the great author of the "Principia," the discoverer of the binomial theorem, and of the "Fluxionary Calculus" to a junior fellowship in Trinity Col-

lege, A. D. 1667, physics and mathematics have had their full and abundant share in the curriculum of this university. If, therefore, there has been a greater leaning toward physics and applied, as distinguished from pure mathematics, it has been accomplished, almost unperceived, under the guidance of men like Stokes, Thomson, Clerk-Maxwell, and his successor, Lord Rayleigh, who combine the highest powers of numerical analysis with the imaginative, constructive, and inventive faculty of Wheatstone and Faraday.

At the sister University of Oxford the case is very different. Here the method of the schoolmen and the misrepresented teaching of Aristotle reigned supreme until our own time. The anachronism was indeed expressed in concrete form by a single word. The "science" which up to 1852 formed one foot of the tripod, with scholarship and history, on which honors were adjudged, was the science of a thousand years before, the metaphysics and moral philosophy of the Stoics—of those who, proposing to teach it, wrote over the entrance to their school, *οὔδεις ἀγεομετρήτος εἴσιτο*, which, in the terms we are now using, may fairly be translated, "Let none unacquainted with physics enter." It was a purely mental analysis of the great problems even then seen to underlie our simplest conceptions of the universe. The change required in this center of learning was therefore from metaphysics to physics; it was a scientific putting of the cart before the horse; a substitution of Pythagoras or Archimedes for Plato or Aristotle, as the latter then and there were studied; namely, in his dogmatic treatises on ethics, politics, rhetoric, and metaphysics, and not in his far stronger genius as a natural historian and zoölogist.

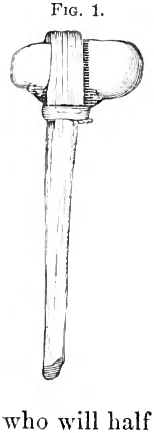
Is it to be wondered that the wrench thus suddenly given produced molecular change; that the impulse overran the neutral point; and that those who previously had been commended for accurate knowledge of the metaphysical attributes of God should require time to learn the internal economy of a Holothurian, the exact chemical constitution of ethylic-diethyloxamate, or the formula for Carnot's reversible heat-engine? Even now, within an ace of thirty years from this intellectual cataclysm, poor old Oxford is only just recovering from a protracted state of vertigo, and settling down again to useful work. It is sad that she should have to chronicle the early loss of one who has been a main agent in the revolution. The Linacre Professor of Physiology [Dr. Rolleston], who began as an orthodox first-classman in the school of *Litteræ Humaniores* in 1850, dies in 1881 at the age of fifty-two, an advanced exponent of modern views in anthropology. —*Popular Science Review.*

THE AUSTRALIAN ABORIGINES.

By GABRIEL MARCEL.

THE recent work by Mr. Brough Smyth relative to the aborigines of the colony of Victoria contains also many curious details respecting the manners and customs of the natives of other parts of Australia. It is evident that the native race is not everywhere equally pure. In the northern part of the continent traces may be observed of immigrations in earlier times of Papuans from New Guinea; of Chinese, whose visits are attested by the lacquered articles, cotton cloths, bamboos, etc., which have been found in the hands of the natives; and of the Malays, who have frequented the northwest coasts for fishing from time immemorial. Nevertheless, the figures of the natives, their arms, their workmanship, have everywhere a strikingly uniform character. Their numbers have fallen off very fast in the face of the extension of the white settlements, partly on account of the fierce wars that have prevailed between them and the colonists, but more in consequence of the inroads of the vices and maladies which they have contracted from the whites. The missionaries have been able to make but small headway in their efforts to convert them, and have exerted no appreciable effect in staying the progress of extermination. Recently the Government has established a bureau for their protection, has allotted lands to them, and opened schools for them, and the few of them that are left enjoy at least a promise of better times.

Fig. 1.

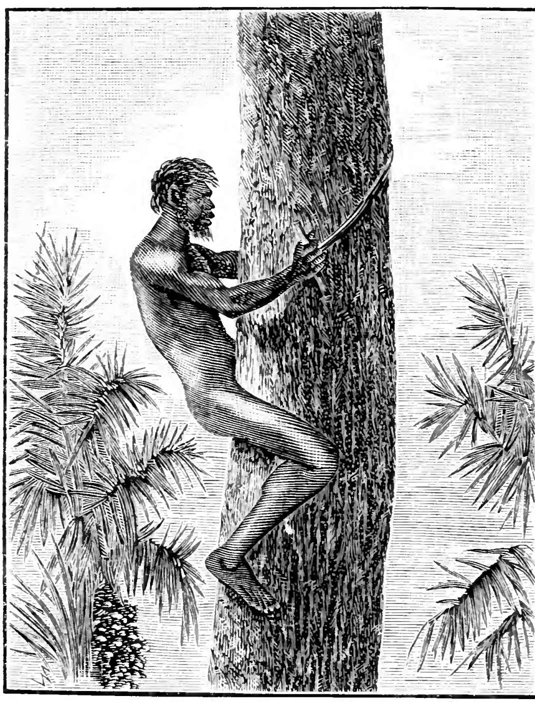


The disappearance of the Australian race has been promoted by certain peculiarities of its own, among which are the belief that no person can die a natural death, and the general practice of infanticide. When a member of a family is about to die, the natives believe it is the result of witchcraft practiced by some neighboring tribe. The relatives of the deceased arm themselves at once, and follow the course that is taken by the first insect or fly that they see light upon the grave of the deceased. It is not from any lack of affection that the mother kills her child, but most frequently because it is impossible to give it food, or because it cries too much, or is stupid, or deformed, or weak; and, along with this incomprehensible hardness of heart, these savages give to their children numerous marks of affection. The same man who will half kill a girl to make her his wife will protect her and love her tenderly after she has submitted to his will. The part of the wife is far from being agreeable. The slave of her husband, she has to carry, besides her child, all the burdens when they travel, to do the hard work, and be ready at any moment to obey the orders of her

lord. He is brutal, and punishes the lightest offense with the lance or hatchet.

Polygamy is universal, but the oldest men of the tribe have the most wives, acquiring them in exchange for their daughters. A number of young men are thus compelled to remain bachelors. When a young man has, after cruel ceremonies and horrible tortures to test his courage, been proclaimed a warrior, he may take a wife. If he is a son of a great warrior, he will have little difficulty in the matter; but, generally, he will have to capture his wife, or buy her from a neighboring tribe, in return for some girl over whom he can exercise a certain degree of control. Since the tribe is only an extension of the family, and all of its members are generally closely related, it is necessary to marry outside of it. Hence three methods of marriage are practiced—free consent, capture, and exchange.

FIG. 2.



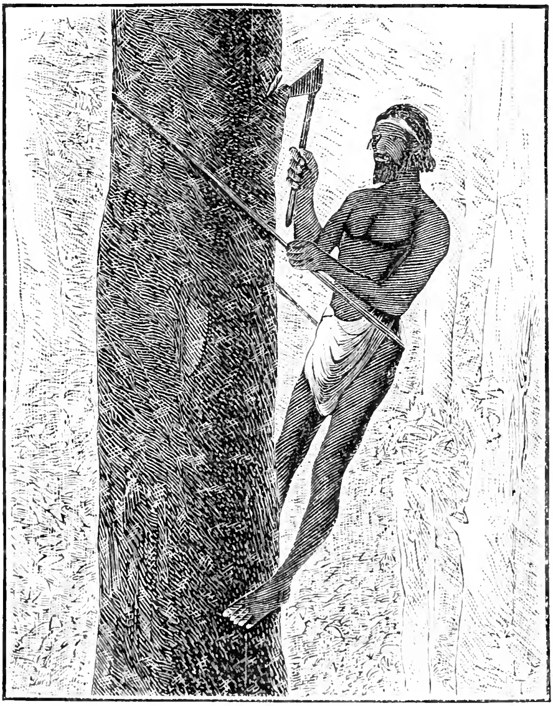
Mutilations, especially of the first phalanges of the left hand, are practiced among the natives; circumcision, tattooing—not regular and complete as in Samoa and New Zealand, but simply in curved lines—are in frequent use. They paint themselves indifferently with white, yellow, and black streaks; blue was unknown among them till the arrival of the Europeans.

The most numerous and most robust tribes are those which live on

the borders of the sea or the rivers, where they are sure of enough food. The tribes of the interior, where water is extremely scarce, are miserable, repulsive, and feeble, their encampments are more primitive, their arms are less well cared for, their dialect is ruder, than among the inhabitants of the coast.

It has been represented that these natives have not the virtue of providence; but they know how to make provision for a bad season. Grey affirms that they save the nuts of the zamia, and Coxen describes the methods which the natives of the northeast employ for preserving oily seeds, gums, and other kinds of food. Whenever a whale or a large fish is stranded on the shore, fires are kindled, and all the families around assemble to get a share of the windfall.

Fig. 3.



Families settling down choose a situation near a forest where they can get the wood they need for their cabins, which are sometimes made of limbs covered with earth, sometimes of the bark of a tree called the stringy-bark. This bark, according to Baron de Bougainville, is very thick and incombustible; it serves both for the walls of the cabins and their roofs, and, as it can be taken off in large slabs, only a few hours are needed to make with it a habitation which gives a perfect shelter. When a savage has found a tree suitable for his purpose, he, with his stone hatchet (*kal baling-carek*, Fig. 1), cuts a

notch in the bark for his great-toe, raises himself up, makes a second toe-hole, and climbs up with a facility, rapidity, and skill, of which we can hardly have an idea. In Western Australia, the helve of the hatchet is pointed, and the natives, after making the notch, stick the tool in the bark and lift themselves up with it. In other parts, they scale very large trees with the assistance of a simple cord of vegetable fiber having wooden handles at its ends (Fig. 2). Sometimes the cord is passed around the tree and the climber, so as to hold him up by his loins. The man hugs the tree with his legs, lifts the rope, draws himself up without slipping back, and reaches the desired height in a very short time (Fig. 3).

For making their canoes the natives choose the bark of certain gum-trees. The species most in favor for this purpose is the red-gum

Fig. 4.

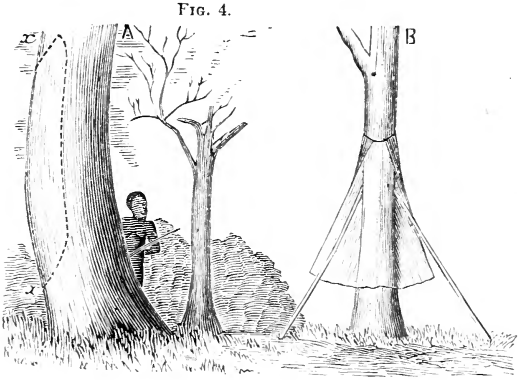
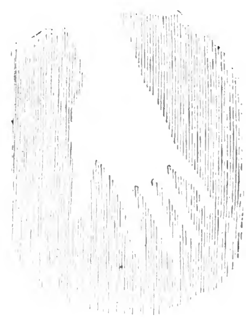


Fig. 5.



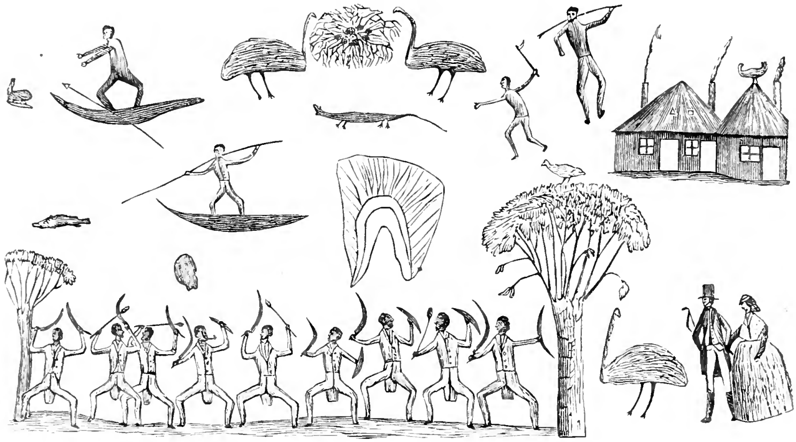
(*Eucalyptus rostrata*), from which the bark can be peeled in large pieces. It is considered desirable to get the bark from a tree that is a little bent, so that it shall be somewhat near the shape of the canoe, and a part of the labor of making the vessel may be saved. The bark is cut according to a specially designed shape, at the points x and x' (Fig. 4, A), and these points are connected by cuts from one to the other. The bark is then gradually peeled off by the aid of the helve of the hatchet and a stick (Fig. 3). Sometimes two sections are made at three and at ten feet above the ground, and connected with a vertical cut (Fig. 4, B). Poles are then introduced between the tree and the bark so as to work out a gradual detachment of the latter. The slab of bark is then given the desired form, and the ends are drawn together with cords or withes. This is one of the most primitive canoes that can be imagined.

These people appear to have a really genial taste for design. Freycinet relates that Captain King found on the walls and the floors of the caves in Clark Island numerous drawings executed with a white earth upon a reddish ground with which the rocks had been covered. Finders discovered similar sketches in a little island in the Gulf of

Carpentaria, representing porpoises, turtles, kangaroos, and a human hand (Fig. 5). At another place in the cave was a figure of a kangaroo followed by thirty-two hunters.

The atlas of the "Voyage of Perron" contains copies of a number of designs by natives of Port Jackson, but none of them are more curious than the one which we reproduce from Mr. Brough Smyth (Fig. 6).

Fig. 6.



Above are a hunter chasing a swan on the water, two emus with their nest and eggs, a native about to strike a large lizard, and two European houses; below, are nine natives dressed in European clothes, holding native arms in their hands, and executing a war-dance; while in the right-hand corner are an emu, and an Englishman, who, with a whip sticking out from his pocket and wearing hunting-boots, gives his arm to a woman whose ample crinoline fairly indicates the time when the figures were drawn.

These first essays of a barbarous race possess a high interest, and cause us to regret that the circumstances controlling the condition of the people have not permitted them to give their tastes a higher development.—*Translated from La Nature.*

UNEXPLORED PARTS OF THE OLD WORLD.

By M. VÉNUKOFF.

I PROPOSE to point out very briefly certain regions of Europe and Asia which have not yet been explored. Some persons may be surprised to hear Europe spoken of in this sense, but there are considerable parts of that continent of which much of interest is yet to be learned, and concerning which our maps are inexact and our geography

is still defective. Extensive geodetic and topographical surveys were made in the principality of Bulgaria and Eastern Roumelia during the war of 1877–'78, but that the geography of Macedonia, Epirus, and Thessaly is far from being exact is proved by the difficulties which were experienced at the Conference of Berlin in defining the boundary between Turkey and Greece. In Russia all the northern provinces, from the frontier of Norway to the Ural Mountains, have been explored only superficially, and the only well-traced lines are those of the coasts and of the beds of the great rivers. The map of Lapland is equally imperfect, the great *tundra* of the Samoieds is wholly unexplored, and but little is known of the northern part of the Ural Mountains, which is probably equally rich in minerals with the middle division of the chain. From the Ural we pass to Nova Zembla, of which the littoral only has so far been examined, but which is destined to afford geologists an interesting study concerning its probable connection with that chain and with the archipelago of Franz-Joseph Land.

The parts of Asia bordering on the Kara Sea and the Arctic Ocean offer many points worthy of the attention of explorers. Among them is the enormous tract belonging to the basins of the Khatanga and Anabara, a country twice as large as France, concerning the geography of which the voyages of Tchékanovsky and Nordenskjöld have upset our old ideas, and which are still only hypothetically represented on our maps. The countries east of the Lena are wholly unknown, and embrace very extensive regions that have never been visited by Europeans. Wrangell has made a sketch of them from information supplied by Siberian natives, but it can not be depended upon. The country of the Tchouktchis is superficially well known, thanks to the labors of Nordenskjöld and previous explorers, but has never been scientifically examined. The extreme northeast peninsula north of the Gulf of Anadir needs a thorough exploration of its interior, for it may become important as a station for whalers, particularly if it should be found to contain coal. The country of the Koriaks, a vast desert region of hardly accessible mountains, traversed by no important river, offers few attractions, but might be made to yield a rich harvest of new discoveries to the naturalist. Kamchatka is better known, but it needs an accurate survey. The geologist would find objects of interest in its central chain of mountains and its active volcanoes; the botanist and zoölogist, in its rich flora and fauna; the landscape-painter, in its majestic peaks with their summits vomiting fire and their slopes covered with magnificent forests; the ethnologist, in tracing the connection between the native population and the people of the Kurile Islands on the one side and of Northwestern America on the other, and in watching the development of a new mixed race, which has originated since the Russians have settled in the country. On the other side of the Sea of Okhotsk we find awaiting a competent explorer the northern

part of Saghalien, an island as large as Ireland; the mountain-chain which rises between the Strait of Tartary and the valleys of the Amoor and Ousouri; the vast spaces of Manchooria; the mountains dividing Corea from China, covered with great forests, and containing so considerable mineral wealth as to afford a profit to the Chinese vagabonds who work for it with the most primitive processes; and the forbidden land of Corea. On the classic ground of the Celestial Empire are spaces larger than Great Britain that may be ranked among unknown lands. Eastern and northern Thibet, the least accessible part of all the empire, presents in particular many interesting problems, the most important of which is that of the river systems. What is the true relation between the rivers which we see hypothetically represented on the map of Thibet and those of Indo-China and India? Is the chain of the Kuen-Lung, which appears on the maps as one of the principal ranges of the continent, really worthy to be ranked with the Himalaya and the Thian-Shan systems? The latter question is now complicated with some apparently contradictory circumstances. The southern part of eastern Turkistan deserves the attention of explorers equally with Thibet. It is the most inaccessible desert of the continent, a land of jade-stone and gold, of camels and the wild horses that are not known anywhere else in the world.

Prejévalsky, during his last expedition, touched a country of quite exceptional geographical interest, the sources of the Hoang-Ho. He was not able to penetrate to the "Sea of Stars" itself, but he saw a considerable part of the narrow valley by which the upper Yellow River flows toward the east. Access to the sources themselves of this great stream has thus become one of the geographical *desiderata*; but no doubt exists concerning the absence of the subterranean connection between the Hoang-Ho and the Tarim, of which the Chinese geographers have often spoken.

The great desert of Gobi has lately been tolerably well explored, but the question is still to be answered whether it is crossed by a chain of mountains connecting the eastern end of the Thian-Shan with the In-shan. The mountains, if they exist, can not be very high, for no large rivers flow from the region, and some streams flow toward it; but they are marked on several maps of China, including that of the Russian staff; and the existence of a direct route between Koukou-Khota and Barkoul indicates that there are springs along the line, and they must have hills to maintain them.

Northern and northeastern Mongolia have been topographically delineated with some exactness, but no naturalist has visited them; and only three or four European travelers have crossed the Kingan range between Mongolia and Manchooria, whose geological structure and mineral, zoölogical, and botanical riches have still to be found out.

Returning along this range into China proper, we enter a country the superficial character of which has been often described, but con-

cerning which the determinations are still very inexact. Consequently, our maps of China are filled with chains of hypothetical mountains, which certain famous *savants* would like to impose upon us as the last word of modern science. Unfortunately for them, Nature has the bad habit of not agreeing with systems that are too learned, even when they are framed by disciples of the most eminent geographers. Anthropological interest is attached to the heterogeneous populations of the western provinces of this vast country, and we may possibly find among them the missing links of the chain that may connect the yellow race with the white race. To make such researches successful, one must of course be an accomplished scholar in Oriental linguistics and philosophy, but the possible results of such investigations are so attractive that I am disposed to believe in their near realization. Similar anthropological and linguistic researches may be undertaken in the southwestern provinces of China, which are filled with aborigines not of Chinese origin ; and hence we may go to Indo-China, the richest part of Asia, of which only the French and the English colonies, the coast regions, and the largest valleys are known, and where the origin of immense rivers is still to be traced.

Japan and the archipelagoes of the Pacific are others among the richest countries, and have attracted much attention from travelers ; but what has been learned about them should only sharpen the desire to learn the more which is still unknown ; and these islands, with their varied populations, afford most profitable studies in language and anthropology.

British India is the best explored part of Asia, and is even better known than some parts of Europe. It does not come within our category ; but the adjoining countries of Afghanistan and Beloochistan still await a scientific exploration of their most important parts. Our geographical knowledge of the Southern parts of Turkistan is also wanting in many points concerning which it would be desirable to know more. The Oasis of Merv, which is so often mentioned in the journals, has never been visited by a scientific traveler. The fundamental question of Turkoman geography is identified with the discovery of the ancient beds of the Oxus and its affluents. Many important advances have been already made in this direction, but much of the desert stretching between the present Amoo-Darya and the mountains of Khorassan still remains to be explored ; and on its competent exploration depends much that is important to the improvement of the country.

Great progress has been made in the last twenty-five years in the exploration of Khorassan, and Stebnitzky's late map of Persia is quite full in relation to that province. Western Persia has been nearly as well mapped, but much is yet to be done concerning the southern part and the interior of the country. The greater part of the interior, however, has been known, from the most remote antiquity, to be a desert,

and is not likely to afford any features of important interest. The same is the case, in a higher degree, with the most of Arabia, which the inhabitants themselves say God created in anger, and which the travels of Palgrave and Blunt show is not likely to afford enough scientific results to pay for the toil and dangers of a thorough examination. Our knowledge of Mesopotamia and Syria is being rapidly increased by the zeal of antiquarian explorers, whose investigations, although they are rather historical than geographical, and concern the past rather than the present, are not without results of contemporary interest. In Asia Minor and Armenia, researches already carried on need to be completed and systematized and made generally applicable to the whole country; and there are spots within three or four days' journey from Constantinople that still need to be thoroughly worked out.

We are back in Turkey, whence we started, but on the southern instead of the northern side of the Hellespont and Bosporus. We might complete our tour by examining these straits, and finding whether they are traversed by a single current, carrying the waters of the Black Sea into the Mediterranean, or by two currents, one superficial and running to the west, the other submarine and directed toward the east—a question that may have a bearing on the future of the countries east of the Black Sea.—*Revue Scientifique.*

WHAT IS A MOLECULE?

MODERN science declares that every substance consists of an aggregation of extremely small particles, which are called molecules. Thus, if we conceive a drop of water magnified to the size of the earth, each molecule being magnified to the same extent, it would exhibit a structure about as coarse-grained as shot; and these particles represent real masses of matter, which, however, are incapable of further subdivision without decomposition. A lump of sugar, crushed to the finest powder, retains its qualities; dissolved in water, the mass is divided into its molecules, which are still particles of sugar, though they are far too small to be seen by the highest powers of the microscope. The physical subdivision of every body is limited by the dimensions of its molecules; but the chemist can carry the process further. He "decomposes," or breaks up, these molecules into "atoms"; but the parts thus obtained have no longer the qualities of the original substance. Hence the molecule may be considered as the smallest particle of a substance in which its qualities inhere; and every molecule, though physically indivisible, can be broken up chemically into atoms, which are themselves the molecules of other and elementary bodies.

No one has ever seen or handled a single molecule, and molecular science therefore deals with things invisible and imperceptible by our senses. We can not magnify a drop of water sufficiently to see its structure; and the theory that matter is built up of molecules depends, like the philosophy of every science, on its competence to explain observed facts. These are of two kinds—namely, physical and chemical. A physical change in the condition of a body is illustrated by dissolving a lump of sugar in water. The sugar disappears, but remains present in the water, from which it may be recovered by evaporation. But if we burn the lump, we effect a chemical change in its condition. The sugar again disappears, and in its place we get two other substances—namely, carbon and water.

Similarly, water is converted by boiling into the invisible vapor, steam; but the change in its condition is physical only, for the steam condenses to water on being cooled. If, however, we pass water through a red-hot iron tube, it disappears, and is replaced by the two gases, oxygen and hydrogen. In the latter case, the liquid suffers a chemical change, or, as we say, is "decomposed" into its constituent elements. Those changes, therefore, which bodies undergo without alteration of substance are called physical; while those which are accompanied by alteration of substance are called chemical.

Turning our attention first to the physical side of the question, let us inquire how far some of the fundamental laws of science are illustrated by the molecular hypothesis. Among the most important of these is the law of Boyle, which declares that the pressure of gases is proportional to their density. The theory under review is based at present on the phenomena of gases, and considers these as aggregations of molecules in constant motion. Their movements are supposed to take place in straight lines, the molecules hurrying to and fro across the containing vessel, striking its sides, or coming into contact with their neighbors, and rebounding after every collision, like a swarm of bees in a hive flying hither and thither in all directions.

We know that air, or any gas, confined in a vessel, presses against its sides, and against the surface of any body placed within it. This pressure is due to the impact of the flying molecules; and the constant succession of their strokes is, according to this theory, the sole cause of what is called the pressure of air and other gases. As each molecule strikes the side of the vessel the same number of times, and with an impulse of the same magnitude, the pressure in a vessel of given size must be proportionate to the number of molecules—that is, to the quantity of gas in it; and this is a complete explanation of Boyle's law. Let us next suppose that the velocity of the molecules is increased. Then each molecule will strike the side of the containing vessel not only more times per second, but with greater force. Now, an increase in the velocity of the molecules corresponds in theory to a rise of temperature; and in this way we can explain the increase of

pressure, and the proportions of such increase which result from heating a gas. Similarly, Charles's important law, that the volume of a given mass of gas under a constant pressure varies directly as its temperature, follows obviously from the hypothesis.

Priestley was the first to remark that gases diffuse through each other. This fact is familiarly illustrated by the passage of odorous gases through the atmosphere. If a bottle of ether is opened in a room, its vapor diffuses through the air, and its presence is soon recognized by the sense of smell. In this case, the ether-molecules may be figured as issuing from the bottle with great velocity; and, if their course were not interrupted by striking against the molecules of the air, the room would be instantaneously permeated by their odor. But the molecular particles of both air and ether are so inconceivably numerous, that they can not avoid striking one another frequently in their flight. Every time a collision occurs between two molecules, the paths of both are changed; and the course of each is so continually altered that it is a long time in making any great progress from the point at which it set out, notwithstanding its great velocity.

We must next inquire how these velocities are measured, and what is their amount. We have seen that the pressure exerted by a gas is due to what may be appropriately called the molecular bombardment of the walls of its containing vessel; and, knowing this pressure, we can calculate the velocity of the projectiles, if we can ascertain their weight, just as we can estimate the speed of a bullet when its weight and mechanical effect are known. Now, a cubic centimetre of hydrogen at a pressure of one atmosphere weighs about one thousandth part of a gramme; we have, therefore, to find at what rate this mass must move—whether altogether or in separate molecules makes no difference—to produce this pressure on the sides of a cubic centimetre. The result gives six thousand feet per second as the velocity of the molecule of hydrogen, while in other gases the speed is much less.

The question of molecular weights brings us face to face with the chemical aspect of the hypothesis; and we have now to examine the support which is given to it by chemical phenomena, and show how wonderfully these are correlated with the physical proofs. Bearing in mind the distinction between physical and chemical changes, we know that we can make a mixture of finely divided sulphur and iron, for example, in any proportion. But these bodies when heated combine chemically to form a new substance called sulphide of iron; and the two classes of products exhibit great differences, which are indicated by a most remarkable characteristic. Chemical combination, unlike mechanical mixture, always takes place in certain definite proportions. Thus, fifty-six grains of iron combine with exactly thirty-two grains of sulphur; and, if there is any excess of either substance, it remains uncombined. This principle is known as the law of definite combining proportions, and the atomic theory, which, in one shape or an-

other, is as old as philosophy, was first applied to its explanation by the English chemist Dalton in 1807. He suggested that the ultimate particles of matter, or atoms between which union is assumed to take place, have a definite weight; in other words, that they are distinct masses of matter. In the combination of the two elements in question, therefore, an atom of iron unites with an atom of sulphur to form a molecule of sulphide of iron; and the union takes place in the proportion by weight of fifty-six to thirty-two, simply because these numbers represent the relative weights of the two sorts of atoms. Now, Dalton may be wrong, and there may be no such things as atoms; but every science postulates fundamental principles, of which the only proof that can be offered is a certain harmony with observed facts; and the chemist assumes the reality of atoms and molecules because they enable him to explain what would otherwise be a chaos of unrelated facts. The combining proportions of substances, then, indicate their relative molecular weights; and, bearing this in mind, we must turn again for a moment to the physical side of the question, to inquire whether, and in what way, the physicist can determine the weight of a molecule.

Water, alcohol, and ether expand when heated, like other forms of matter, but they do so very unequally. Their vapors, on the other hand, are expanded by heat at exactly the same rate under like conditions. The theory supposes that the molecules which are close together in the liquids become widely separated when these are converted into vapors; and the action of the particles on each other becomes less and less as they are driven farther apart by heat, until at last it is inappreciated. When the molecules of the vapors in question are thus freed from other influences, it is found that heat acts in an exactly similar manner upon each of them; and this is found to be true of all gaseous bodies. The obvious explanation in the case before us is, that there are the same number of particles within a given space in the vapors of all three liquids. This is the law of Avogadro, which is formulated as follows: "Equal volumes of all substances, when in the form of gas, contain the same number of molecules"; and we shall see how simply this conception is applied for the purpose of determining the molecular weights of all bodies which are capable of being vaporized. It will be understood that we are still dealing, as in the case of chemical combination, with relative weights only. We have no means of ascertaining the absolute weight of a molecule of any substance; but we can state with perfect accuracy what relation these weights bear to one another. For this purpose, the molecule of hydrogen, which is the lightest body known to science, has been selected as the unit. Calling the weight of a litre of hydrogen one, we find by the balance that a litre of oxygen weighs sixteen; and as, by Avogadro's law, both litres contain the same number of molecules, the molecule of oxygen is sixteen times heavier than that of hydrogen. The mo-

lecular weight of any substance, therefore, which can be brought into the gaseous condition, is found by simply determining experimentally the specific gravity of its vapor relatively to hydrogen.

In this way the physicist ascertains the molecular weights of all easily vaporizable bodies, and these are found to be in uniform and exact agreement with those which the chemist deduces from the law of combining proportions. The molecular hypothesis is thus brought to a crucial test; and two entirely independent lines of inquiry agree in giving it support of such a character as compels conviction. The law of gravitation and the undulatory theory of light do not command more cogent circumstantial evidence than this.

We have now briefly reviewed the fields from which the certain data of molecular science are gathered. We have weighed the molecules of gases, and measured their velocity with a high degree of precision. But there are other points, such as the relative size of the molecules of various substances, and the number of their collisions per second, about which something is known, though not accurately.

With regard to the absolute diameter of a molecule and their number in a given space, everything at present is only probable conjecture. Still, it may be interesting to state the views which are held on these questions by such investigators as Sir William Thomson and the late Professor Clerk-Maxwell; but we give these without attempting to indicate the character of the speculations on which their conclusions rest.

Summing up, then, both the known and unknown, we may say that the molecular weights and velocities of many substances are accurately known. It is also *conjectured* that collisions take place among the molecules of hydrogen at the rate of seventeen million-million-million per second; and in oxygen they are less than half that number. The diameter of the hydrogen molecule may be such that two million of them in a row would measure a millimetre. Lastly, it is conjectured that a million-million-million-million hydrogen molecules would weigh about four grammes; while nineteen million-million-million would be contained in a cubic centimetre. Figures like these convey no meaning to the mind, and they are introduced here only to show the character and present state of the research.

A few concluding words must indicate the tremendous energy residing in the forces by which the molecules of matter are bound together. The molecules of water, for example, can not be separated from each other without changing the liquid into a gas, or, in other words, converting the water into steam; and this can only be accomplished by heat. The force required is enormous; but, since the determination, by Joule, of the mechanical equivalent of heat, we are able not only to measure this force, but also to express it in terms of our mechanical standard. It has been found that, in order to pull apart the molecules of one pound of water, it is necessary to exert a mechan-

ical power which would raise eight tons to the height of one hundred feet. Such is the energy with which the molecules of bodies grasp each other; such is the strength of the solder which binds the universe together.—*Chambers's Journal.*

SKETCH OF JAMES CRAIG WATSON.

By ALEXANDER WINCHELL, LL. D.

JAMES CRAIG WATSON, Professor of Astronomy in the University of Wisconsin, and Director of the Washburne Observatory at Madison, Wisconsin, died on the morning of November 23, 1880, after an illness of one week, at the age of forty-two years and ten months. Professor Watson was one of the most gifted and distinguished of modern astronomers, and his life-work is identified with the name of the University of Michigan.

He was born of American parentage, during a sojourn of his parents in Middlesex (now Elgin) County, Ontario, January 28, 1838. The mathematical genius revealed by the boy at the early age of nine determined the father to secure him a liberal education, and the family accordingly removed to Ann Arbor in 1850. Here James displayed equal aptitude for mathematical and linguistic studies, and, being prepared for college, almost without the evidences of effort, he entered the University of Michigan in the autumn of 1853. He attained equal scholarly distinction as a student of ancient and modern languages and of mathematics. It is said that, before the close of his junior year, he had performed the phenomenal feat of reading from beginning to end the "Mécanique Céleste" of Laplace. During his senior year, he was the solitary pupil of Dr. Brünnow, and graduated in 1857. His mechanical tact was such that, in the absence of a mathematical bent, he would have become an eminent mechanician and inventor. While in college, some of his spare hours were spent in grinding lenses and the construction of a telescope. Other portions of his time he was compelled to devote to the earning of means to defray collegiate expenses.

During the two years succeeding his graduation, he was employed as assistant in the Observatory, and in the prosecution of studies for his second degree. In this work he displayed such remarkable aptitude as an observer, and such marvelous rapidity in his computations, that, on the retirement of Dr. Brünnow, in June, 1859, young Watson succeeded him in the chair of Astronomy. He was already known as a frequent contributor to the "American Journal of Science," Brünnow's "Astronomical Notices," Gould's "Astronomical Journal," and the "Astronomische Nachrichten," of Altona. Not less than twelve

communications, written before he was twenty-one, are recorded in the Royal Society's "Catalogue of Scientific Papers," which also enumerates twenty-one others between 1859 and 1874. His wonderful keenness as an observer was signalized, while yet an undergraduate, by the discovery of a comet on the 29th day of April, 1856, and, four months after graduation, by the discovery of a planet on the 20th of October, 1857, which, however, proved to have been observed by Luther a few days before, and has been named *Aglaia*. His observations of Donati's comet, in 1858, possess a standard value, and his computation of the orbit is recognized as authoritative. The interest awakened by this comet prompted to the preparation of "A Popular Treatise on Comets," published early in 1860.

In 1860 Dr. Brünnow resumed the directorship of the Observatory, and young Watson was assigned to the chair of Physics in the university, which he retained for three years, when, on the final retirement of Dr. Brünnow, Watson was made Professor of Astronomy and Director of the Observatory, a position which he held and honored for sixteen years. Scarcely had he been clothed with full control of the instruments, when he resumed his remarkable career of discovery. There seemed almost a magic in his powers. Unrecognized celestial objects seemed to crowd spontaneously upon his notice. On September 14, 1863, he made his first independent planetary discovery. This was *Eurynome*. On January 9, 1864, he discovered the comet since known as 1,863, VI, which Respighi, as it proved, had already noted. On the 9th of October, 1865, he discovered a planet which also proved to have been announced by Peters, and has since been named *Io*. He discovered *Minerva*, August 24, and *Aurora*, September 6, 1867. During 1868 he added no less than six minor planets to the solar system, furnishing the only instance in which the list of planetary discoverers presents the same name four times in immediate succession.

Meantime he was engaged upon a work which might well have engrossed all his powers, and must have quite exceeded the abilities of any but a gifted mathematical genius. It was no less than a complete digest of the results and methods of all the great writers on theoretical astronomy, and an independent development of the great principles of the science. "Having carefully read the works of the great masters," he says in his preface, "my plan was to prepare a complete work on the subject, commencing with the fundamental principles of dynamics, and systematically treating, from one point of view, all the problems presented." This broad plan, conceived by a young man of twenty-eight, and completed when twenty-nine, was executed with ability so commanding, that the work, on its appearance in 1869, was immediately accepted as an authoritative exposition of the higher principles and processes of dynamical astronomy, and was made a text-book at Leipsic, at Paris, and at Greenwich. The same year he was sent by the General Government on an expedition to observe the

solar eclipse at Mount Pleasant, Iowa, and, in 1870, to Carlantini, Sicily, for a similar purpose. In 1874 he was appointed to the charge of an expedition to Peking, China, to observe the transit of Venus. His observations were favored by the weather, and conducted with consummate skill. The results, though reduced and discussed, are not yet published. Even at the antipodes, fresh discoveries awaited him. He had already raised his list of planetary discoveries to seventeen, and now added *Juewa*, the eighteenth. In 1876 he was one of the Judges of Awards at the Centennial Exposition, and wrote the celebrated "Report on Horological Instruments." In 1878 also appeared his "Tables for the Calculation of Simple and Compound Interest," a work which, in spite of the subject, is marked by great originality, and demanded a vast amount of wearisome labor. The same year he was sent by the General Government in charge of an expedition to Wyoming, to observe the total solar eclipse. Professor Watson, having long entertained a belief in the existence of an intra-Mercurial planet, as well as of an extra-Neptunian one, gave special attention at this time to a search for the former, and was the first astronomer to note certainly (July 29, 1878) the existence and position of the planet Vulcan. He also satisfied himself of the existence of a second intra-Mercurial planet. This brought the number of his original planetary discoveries to twenty-six (including one lost July 29, 1873, and two anticipated). He was now animated by an intense desire to control instruments of suitable power and adjustment to confirm his last observations, and enable him to detect the outlying planet beyond Neptune. Coincidently came the invitation to assume the charge of the Washburne Observatory at Madison, Wisconsin, which was to be improved and newly equipped with instruments far more efficient than those at Ann Arbor. The temptation was great, but he naturally clung to his alma mater, whose authorities made such efforts as they thought authorized to content their astronomer. But the requisite means could only be obtained by a grant from the Legislature, a measure defeated by an inadequate appreciation of the honor shed upon the State by such a name as Watson's. Reluctantly, but sustained by a high and noble aspiration, he removed, in the summer of 1879, to Madison, and immediately devoted himself with intense energy to remodeling the observatory structure, and introducing some original provisions thought to be suited to the special researches on which he was bent. A cellar twenty feet deep was sunk at the bottom of the first slope of Observatory Hill. Into this, light was to be thrown through a long tube, from powerful reflectors on the top of the hill. This, with other accessory work, was actually in progress, when a severe cold brought on peritonitis, which over-confidence in his physical powers permitted to reach a fatal stage before medical aid was summoned. His remains, accompanied by an escort from the University of Wisconsin, were removed to Ann Arbor, where they lay in

state, in the university, during the 25th of November, and, on the following day, with due honors and imposing ceremonies conducted by his late colleagues, were reverently laid beneath the shade of Oakwood Cemetery.

Professor Watson possessed extraordinary intellectual endowments. His quickness of perception nothing escaped. His mathematical intuitions scorned the ordinary processes of calculation, and gave him a masterly command of mathematical logic and formulæ, which made so many portions of his work on "Theoretical Astronomy" strictly original, and all parts virtually his own. Yet he never mentions any claim to originality, but pursues his majestic intellectual march with the dignity almost of an inspiration. His memory served him equally well. It was both circumstantial and philosophical. Every new observation was immediately illuminated by all which he had previously observed or known, and he saw instantly the proper conclusions. His mechanical gifts gave him perfect command of instruments and their construction, and the Washburne Observatory would have been equipped with several of his inventions. His versatility extended to matters of business. He was for years the actuary of the Michigan Mutual Life Insurance Company, and performed service pronounced invaluable. He managed his private means with such success that he died possessed of a considerable fortune, which his will secures to the National Academy of Science. Physically, he was vigorous and healthy, and reached, in the last years of his life, a weight of two hundred and forty pounds. His religious nature held fast to the fundamental religious beliefs. He used to say it is impossible for a mathematician to be an atheist, and his works offer frequent recognition of the being of the supreme Creator and Governor of the universe.

The world was not slow to recognize his worth. He was elected a member of the National Academy of Science in 1867, and of the Royal Academy of Sciences in Italy in 1870. He received the degree of Doctor of Philosophy from the University of Leipsic in 1870, and the French Academy of Sciences conferred upon him the Lalande gold medal for the discovery of six new planets in one year. Yale College honored him with the degree of Doctor of Philosophy in 1871. In 1875 the Khedive made him Knight Commander of the Imperial Order of Medjidieh of Turkey and Egypt. He was elected member of the American Philosophical Society in 1877, and received, the same year, the degree of Doctor of Laws from Columbia College.—*American Journal of Science.*

CORRESPONDENCE.

SELF-GOVERNMENT IN COLLEGES.

Messrs. Editors.

YOUR editorial on "Self-Government in Education," in which you give an account of the interesting experiment that has proved so satisfactory at Amherst College, suggests to me that Amherst is by no means a leader in applying the principle of self-government among students. In saying this I imply no detraction from the credit due to Amherst; on the contrary, it is rather a subject of congratulation that this college has been so conspicuously successful in carrying out a policy the importance of which has been long recognized, but which could not always be carried into effect.

A little over fifty years ago, the University of Virginia was founded as a group of independent schools in which students were permitted perfect freedom in the election of courses of study; and in their relations with the faculty the system of espionage, so universal in other educational institutions, was entirely discarded. The chairman of the faculty was of course brought into contact with students who abused their freedom, but the student's responsibility as a man was always recognized, and no trammels were imposed upon him beyond the obligation to respect the rights of others. It was assumed that he knew thoroughly the object to be attained by his attendance at the university, and the obligations implied in association with polite society. If he should fail to exercise enough diligence to win success in the final examinations, he himself was the only loser, and the opportunity was afforded him to try the same course another year. But if his example was deemed bad, or any disturbance was traced to him by ordinary methods without espionage, private admonition was bestowed by the chairman, or he was advised to leave. This advice, thus quietly given, was adopted, and the publicity of expulsion usually avoided. From personal experience in this institution ten years ago and again five years ago, the writer does not hesitate to say that as a student he enjoyed all the liberty that is afforded him in New York City as a member of society.

In 1866 the University of South Carolina was organized upon the same general plan that had been long carried into effect in Virginia, and with similar results. Owing to political complications in that State, the University was disbanded in 1870, but during its existence the principle of self-government among students was carried out in full. A students' court was occasionally held, and on no occasion did conflict arise with the faculty.

In 1870 a system of local self-government for the students was adopted in the State University of Indiana. The experiment has been on the whole successful, and a description of many of the details has lately appeared in print. There were at times difficulties which seemed to necessitate total abandonment of the plan; but each year's experience has given strength, and no return to the old system is now considered advisable.

The late report of the President of Harvard affords much that is interesting in relation to methods of college instruction and discipline. The growth of individual freedom for the student has been as noticeable as the increase of breadth in the scope of the university. The same remark applies to Columbia College, as shown by the last annual report of President Barnard. Indeed, in all of our best institutions of learning the day of espionage is past, recitation-marks are to a large extent abandoned, and students are regarded as agents that are not only free, but also self-respecting, responsible, and possessed of enough common-sense to appreciate the objects to be attained by entering upon a course of college study.

But the appreciation of self-government is not wholly confined to those who take part in the work of our higher institutions. In the columns of the New York "Evening Post," last December, appeared a series of articles on "Self-Government in Schools," in which the writer, one of the most successful teachers of our city, gave an exceedingly instructive recital of experiments which he has been cautiously conducting for a number of years past, to test the advisability of substituting the freedom of the republic for the centralized power of an autocracy in the schoolroom. He has found that a large measure of self-government is quite admissible, even where pupils are far below the age at which admission to college is possible. The president of the school republic subjected himself to the same laws by which juvenile voters were bound, and in the end found he had nothing to regret.

Indeed, every intelligent teacher in an intelligent community to-day, whether his sphere of duty be in the lecture-room, the class-room, or the schoolroom, has been

obliged to adapt himself to the evolution of society. If he fails to respect that freedom of thought, of belief, of action, which our civilization makes necessary in all social relations, he finds it necessary to seek other fields where social evolution is not sufficiently advanced to make him an interloper. The same spirit in society which has caused the abolition of the birch rod in school, except in cases of peculiarly low personal organization, has caused the abolition of espionage in colleges and universities. In calling the attention of your readers to the methods by which success is attained in institutions like Amherst, where not only the right but the duty of self-government among students is insisted upon, you are aiding the work of educational reform, and all such efforts are entitled to the acknowledgment of those whose work is education.

W. Le Conte Stevens.

40 West Fortieth Street, New York, *July* 23, 1881.

INFORMATION WANTED.

Messrs. Editors.

Will you permit me through the columns of your journal to ask for a scrap of information that I have been unable to obtain from any books at my command, or from any other source. Infesting the islands of Lake Erie is an insect which from all accounts plagues human beings in much the same manner that the chigoe or chigre—commonly called jigger—of the South is said to. The islanders call this insect a "midget," also a "jigger," and say that it is most numerous in bushes or the undergrowth of the woods; that it is almost invisible to the naked eye; and that when it effects a lodging on the human body it bores through, and lies under, the skin, causing the very annoying and sometimes painful "bites" that are experienced by visitors to the islands. I have frequently suffered from these "bites," which are far more distressing than the most aggravated mosquito-bites, but have never been able to find anything of the little pest that gives them. I am told, however, that, if a "bite" is examined as soon as it begins to itch, the "midget," an infinitesimal yellow insect, may be seen in its center. The "midget" seems to be unlike the chigoe of the West Indies and South America, judging by cyclopedic accounts of this latter insect, only in the respect that it does not, as far as I have been able to discover, rear its progeny under the skin it bores into. Perhaps you, or some of your readers, will be kind enough to inform me what the "midget" is, its true name, etc. Respectfully,

Dean V. R. Manley.

Toledo, Ohio, *July* 16, 1881.

EDITOR'S TABLE.

THE LESSONS OF THE BOSTON "LADIES' DEPOSIT."

The "Atlantic Monthly" did well in publishing in its July issue two articles on the "Ladies' Deposit," a fraudulent banking concern in Boston, of which so much was said last year. One of these articles, by Mr. Henry A. Clapp, gives a history of the scheme, and is evidently written with care and with good knowledge of the facts. The other paper is by Miss Mary Abigail Dodge, who had some experience with the institution, and she presents the feminine side of the case. As the excitement of the affair is now passed away, and we have the main facts fairly before us, it seems proper to look a little into the lessons it teaches; and to do this it will be desirable to recall briefly its leading features. In this we follow the statements of Mr. Clapp.

By whomsoever planned, the scheme of the "Ladies' Deposit" was carried out by a woman named Howe, and she was undoubtedly its master-spirit. The revelations at the sequel show her to have been a vulgar female impostor, a clairvoyant, and fortune-telling adventuress, who had run a long career of petty crime in New England. She first married a half-breed negro, or Indian, named Solomon, who is now living in Rhode Island. They lived together some thirteen years, but the marriage was void on account of the law against the union of persons of different colors. She next married a man named Lane, or Chase, Mr. Solomon being a diligent promoter of the second union. Lane is said to have died at sea, when she married Florimund L. Howe, a house-painter and dancing-master, who is her present husband. The pair adventured

about the country for several years, getting a miserable living in precarious ways, and the woman's conduct was at times so "queer" that in 1867 she was sent to the State Lunatic Asylum in Taunton, where she remained two years. In 1875 she was caught in the perpetration of an elaborate set of frauds and sent to jail, but got out before the expiration of her time through a technical mistake in her indictment.

She is represented as illiterate and in many ways very ignorant, but "she has always been a keen observer, a quick learner, and a shrewd student of human nature. It would be more nearly correct to call her unmoral than immoral; for from her extreme youth she appeared to have a serious constitutional difficulty in discerning the difference between right and wrong, between her own property and her neighbors'. All her thieving has been marked by a grand air of unconsciousness, rather than by eager, covetous greed. Her disposition seems to be somewhat good-natured and generous, and to show a kind of native *bonhomie*, and at the height of her prosperity as a 'banker' she became very popular with a certain set which was especially rich in mesmerists, fortune-tellers, and female physicians of the irregular sort." She has "abundant cunning," "a great natural gift of utterance," "a singularly plausible manner," and to her other accomplishments it must be added that "she is one of the most exuberant, spontaneous, imaginative, and unnecessary liars that ever breathed."

This woman at length planted herself down in Boston as a "banker." When she began, or how she began, is involved in mystery. Her scheme seems to have been copied in its main features from that of a Bavarian swindler—an ex-actress named Adèle Spitzeder—"which was operated in Munich from 1869 to 1872, and by which the Bavarians were cheated out of millions of dollars. . . . Both opened banks of deposit, promised preposterous returns of interest, and successfully invited loans of money from the public. Neither had any pecuniary capital or offered any security, the sole and sufficient reliance of each being upon her own impudence and the combined cupidity and credulity of her customers. Each made friends by playing the Lady Bountiful upon occasion, had a mixed party of gulls and knaves committed to her cause, drew herself out of poverty and into luxurious comfort by means of her bank, ended her career in prison, and left assets enough behind her to pay her creditors a dividend of about five per cent." It is significant that the astounding Bavarian fraud had run its course and exploded, and was reported all over the world seven years before the successful repetition of the experiment was made in Boston.

The main trick of Mrs. Howe was, however, a shrewd improvement upon the Bavarian method. For while Fräulein Spitzeder took deposits from everybody who would make them—high and low, rich and poor, male and female—Mrs. Howe artfully restricted the benefits of her institution to women, and to those, moreover, of small means. No woman owning a house could make a deposit, and no deposits were received less than two hundred dollars, nor more than one thousand dollars. Interest at the rate of eight per cent. per month was paid every three months—that is, twenty-four per cent. quarterly—and the payment was in advance. To the question how it was possible to pay such large interest, the reply was, "We never disclose the methods by which we do business"; "we do not solicit"; "you need not deposit unless you wish"; "we never give references." But, notwithstanding this, it was stated that the "Ladies' Deposit" is a charitable institution for the benefit of single ladies, old and young, of small means, and it was obscurely intimated that the money was intrusted to the

Boston agency for this charitable use by a rich "Quaker Aid Society" of Virginia. Mrs. Howe refused to tell how the funds thus derived were invested, because, as she craftily said, "she was afraid of the displeasure of her superior officers." Yet, thoroughly baseless as was the project which could give no open account of itself, and utterly absurd as were its promises, it nevertheless had a rushing success. Each new depositor had to be introduced by a previous depositor. There was a great show of strictness in inquiring into their fitness. The first depositors, when they had got their enormous interest, reported it to their friends, and the craze spread rapidly among the Boston women to avail themselves of the speculation. That they were the recipients of a charity made no difference. The bank would have nothing to do with men, and constantly encouraged the idea that women were abundantly capable of transacting their own business without masculine advice. And so money poured in by the thousands. The big interest was paid out of the influx, and if a depositor wanted her money back she could have it any day but Sunday, and with it she got the curt notice that she need not apply again. The result was that the "miserable old rogue," with her "swindling savings-bank," in the course of a few months drew from the pockets of ten or twelve hundred New England women no less than half a million dollars. The "Boston Advertiser" at length attacked the concern vigorously, and it collapsed in three weeks. A few of the earlier depositors received their large interest, and got out also with their principal; but when the scheme was pushed into insolvency there remained only five per cent. of their investments for some eight hundred depositors.

As was natural, the women who had walked into this trap and lost their money were roundly denounced for their credulity and business incapacity. Miss Dodge resents this charge in her usual spirited way, launches profuse invectives upon the men who broke up the fraud, and, while not excusing Mrs. Howe, defends her sex from the assaults of masculine "insolence, ignorance, and stupidity." She proposes to show that "the history of the Ladies' Deposit does not demonstrate the credulity of women, the immorality of women, or the educational or political incapacity of women." If not successful in proving these positions, she, at any rate, shuts the mouth of her masculine critics by showing that men too are abundantly imposed upon and cheated, and are therefore credulous and stupid as well as the women.

The subject is here widened, and our chief interest in the affair relates to this aspect of it. What are the conditions that made this transaction possible? What are the causes that led to it and which lead to other kindred results? The particular event has passed away, and in itself is of but little moment; but what sort of a tree is that which bears such fruit? The state of mind that produced it still continues, and we may expect the same things to be done again and again, with only a change of names, forms, and tactics. That which has just now had a conspicuous feminine expression is by no means wholly an affair of sex, but is a common phenomenon. The Ladies' Deposit was in fact but a drop in the bucket compared with the omnipresent impostures and cheats of all grades and qualities which are transacted everywhere. What is the condition of mind which leads to them?

We state nothing new in saying that such impostures as Howe's bank prove a widespread deficiency in mental cultivation. It has been urged that there is a gross want of instruction in our schools in the elementary principles of economics, a knowledge of which would serve as a protection in emergencies of

this kind. Undoubtedly more of political economy in our common-school education would be useful, but it must be remembered that our swindles are by no means limited to the financial sort, while the public mind is probably more alert in this direction than in any other. To rectify the evil by the application of special knowledge would require scores of new subjects to be introduced into our public-school curriculum. Besides, had political economy been taught in the New England schools as other things are there taught, we are not sure that it would have made much difference with the chances of Mrs. Howe's banking adventure. The difficulty was not so much a lack of knowledge on this particular subject as a lack of that mental preparation which would qualify for meeting the whole class of impositions of which the Ladies' Deposit was but a single example.

The Boston women were undoubtedly cheated through their credulity, and this state of mind was palpably exemplified by a thousand of them. But the same state of mind is exhibited by many other thousands of both men and women all over the country; and it is this which has to be met by education before any efficient protection can be gained against its mischievous results. Credulity is easy belief, and the correction of it is, of course, hardness of belief. The credulous person is careless of evidence, and is, therefore, readily duped; the only remedy for this is doubt, distrust, an appreciation of the importance of evidence, and a trained capacity to judge of it. It is necessary that this state of suspicion and questioning become a habit of the mind, and the sifting of evidence in practical affairs a distinct branch of mental cultivation. To escape the evil effects of credulity it is needful that disbelief as an attitude of mind be encouraged as a virtue. The resistance to evidence must be active and vigorous until it is proved to be not spurious and illusive, but sound and valid. Our current culture is here profoundly at fault. Literary education, as such, does not favor this habit of mind; scientific education properly pursued leads to it necessarily. Literature flourished in its highest forms in the ages of credulity, while modern science only arose with the growth of the spirit of doubt. Training in the methods of scientific study seems, therefore, to us, the only adequate remedy for that laxity of thinking and dull credulity of the popular mind in which widespread deceptions and impostures have their origin.

But science also greatly helps us here in the things it teaches. It familiarizes the mind with the conception of an order in human life, the invincible operation of cause and effect in social affairs, and the laws of proportion between actions and consequences to which all persons are subject. That there are natural laws in society which work out their inevitable results is a lesson that requires to be learned as well by the individual as by the state; and scientific education alone can familiarize the minds of the young with this vital truth.

Here our literary education fails. It does not reach, and expound, and enforce this class of ideas. It is so thoroughly verbal and critical in form and spirit as actually to arrest the mind on its way to the study of things. In this way absorption in literature becomes a barrier to science, which, by its nature, must deal directly with facts and principles. Science merely addressed to the apprehension, and lodged in the memory like literary acquisitions, is not true science; and little would be gained by introducing social science into our schools, to be pursued there in the manner of other studies. Literary culture, as it predominates in our educational institutions, neither prepares the mind to deal intelligently with questions of evidence nor does it imbue it with right conceptions of social order

and the laws of human relation, and it, therefore, affords but little protection against those vagaries and extravagances of belief which have their root in credulity.

Miss Dodge's apology for the women, in the "Atlantic," is a good illustration of this. Keen, brilliant, thoroughly cultivated as she is, she does not seem for a moment to recognize that the first duty of every woman introduced to Howe's bank was to demand and insist upon the clear evidence of its validity. She does not seem to consider that intelligence or judgment of facts had any function in the affair. Promises certainly extravagant were made, and stories certainly improbable were told, and they were all swallowed without a serious question, but Miss Dodge can see no credulity in it! The notion that the concern was a grand charity appeared so possible, so probable, and so noble, that the poor women were justified in investing in it without any of those precautions that are dictated by universal experience in these matters. Indeed, Miss Dodge seems to think that Howe's bank is a kind of ideal type of beneficence on which this miserable world might well be remodeled. In the good time coming we are entitled to expect boundless largess, and a thundering rate of interest for everybody. She says: "If there had been a great charity at the basis, I do not see how any wiser mode of distribution could have been framed. In view of the inexpressible relief which was afforded in the dozen or so cases of which I learned in the course of the discussion, I feel a thrill of regret whenever I remember that there was nothing in it."

As a matter of probability, that is of evidence as a basis of action, Miss Dodge thinks that eight per cent. a month is not half so incredible or absurd as the working of the present order of nature. With God's government of the world at a paltry six or seven per cent. annually she seems disgusted, declaring, "In regard to general probability I candidly avow that no originality and no magnitude of charity is so incredible as that the Omnipotent Creator of the world should let things go on as they are."

Miss Dodge reasons that the women were excusable for patronizing Mrs. Howe's bank with its magnificent promises because people do actually get benefactions often princely in all sorts of irregular and improbable ways. Dr. Cullis's Home for Consumptives in the heart of Boston, professedly supported by prayer alone, and the Woman's Faith Home for Incurables, in Brooklyn, supported also as is said by faith and prayer, are thought worth referring to, and she adds, "If Christ could fish up money out of the sea wherewithal to pay his taxes, and if he said, 'He that believeth on me, the works that I do shall he do also, and greater works than these shall he do,' why should it seem a thing incredible that he should pluck from the pockets of the rich a hundred-fold or ninety-six-fold the slender means of the deserving poor?"

These are side-considerations for her religious critics, but Miss Dodge thinks that politics teaches the same lesson. She says, "No one can live long and intimately in political circles without being prepared for any development whatever of generosity and magnanimity." Most true!—and alike in Howe's bank and in politics we are not to inquire too curiously into the sources of the generosity. It was the pride of Tweed that he took splendid care of his friends, and the magnanimities of political circles are too generally in proportion as politicians are thieves—they are proverbially generous with the public money! But, even where politicians are not thieves, their circles are full of bounties in the shape of offices and patronage that come as chance advantages to the undeserving, like lottery-prizes

and runs of luck at the gaming-table. In this aspect of its influence the school of politics is thoroughly demoralizing. Nothing is better calculated to subvert all manliness and independence of character than the habit, now become so general in this country, of making politics a business, and depending upon the bounties of government as if it were a kind of earthly providence. It is in the wise order of things that people shall depend upon their own efforts, and prosper through the virtues of industry, frugality, and self-denial. There will be misfortune, and there is a function for discriminating charity; but no teaching is more unwholesome than that which encourages people to count upon the generosity of the rich, government, favor, or something to turn up. Miss Dodge's view of life does not correspond to the realities of life, and is, therefore, a bad preparation for the experiences of life. Quite other views must prevail before we shall see the last of such pitiable experiments as that of the Ladies' Deposit.

STATE EDUCATION.

We last year republished an article by Sir Auberon Herbert, questioning on various grounds the policy of state education. We received several answers to it of various merit, and still more various logic, but they all agreed upon one thing—that state education is indispensable to the preservation of the republic.

We print this month an answer to Mr. Herbert, which is as able as any that have reached us, and has a kind of tacit authority as coming from a public official engaged in the special work of organizing and consolidating a state school system. The writer, Mr. Charles S. Bryant, is Secretary of the High School Board of the State of Minnesota, which is charged with the duty of prescribing and adjusting the courses of study to be pursued in a concatenated or unified system of state schools, from the primary to the university. Mr. Bryant is an advocate of state education in its most comprehensive form, and he also maintains that the right of the state to take charge of this great work is necessary to its self-preservation.

We are abundantly told that this is, to all intents and purposes, a settled question; that government education is nothing less than manifest destiny, and the most foregone of all American conclusions. And we have just here already one of the fruits of the experiment—the borrowing of the political method of buncombe and bullying to force the acceptance of a desired measure, and stave off criticism as a matter of no account. But it is necessary that the subject should be freely discussed, and the more necessary that the principles involved should be thoroughly canvassed, and the objections to the policy fully pointed out, because of the great popularity of the policy and the disposition to push it to its utmost extremes. The question is no longer of the expediency of giving state aid for the primary instruction of the children of the indigent classes who claim to need assistance; but it is whether the government shall undertake this work in all its grades, and take the property of the people to make this whole service a gratuity.

The advocates of government education are given to representing it as an issue between state education and no education at all; and the opponents of the measure are often stigmatized as being in favor of illiteracy and ignorance. But this is a profound mistake. State education is intelligently and earnestly opposed in the highest interest of education. The intervention of the state is resisted because it can not do in the best manner what it undertakes to do—because education by authority and political machinery must fall to a lower standard than that which

has been attained by former methods. Mr. Bryant argues for the state compulsory system as against the voluntary system, but the great advancements of civilization have been incontestably made by private enterprise, and spontaneous coöperation among the members of the community, and with these things the state has only meddled to hinder. The state originates nothing; its highest office is simply to secure the conditions under which the voluntary combinations of individuals for desirable objects shall have the fullest and freest play. Nor is the progress of education any exception to this law. The work of originating and extending knowledge, and of diffusing it by the formation of schools, the organization of societies, the institution of academies, and the establishment of colleges, has always been mainly done by the individual forces of society working under voluntary coöperation and independent of government. Besides, all the tendencies of modern progress are to give larger scope to private enterprise, and to relinquish to the people prerogatives that formerly belonged to government. It is now proposed to contradict this law of advancement by surrendering to the state the whole duty of directing the mental development of its citizens.

Mr. Bryant maintains that the right of state control in the matter of education is a necessary consequence of state sovereignty, and he argues that, in the course of political development, the family is superseded, the state assuming the parental functions. He says: "The child passes, in any organized society, through all the grades in the related social state. In the same order, also, government passes on, until it rests in the control of sovereignty, *the state*. And the right of the state to the custody and control of the citizen is as complete as the right of the parent to the control of the infant child. These are only the natural laws belonging to the several relations in the growth of society in all artificial conditions, under all governments. State control, therefore, comes into rightful exercise of authority over the education of every human being entitled to the privileges and protection of government. The particular age at which state authority may rightfully interfere in this relation is a matter of state policy and sovereign discretion."

Here, again, the law of progress is misread. Nothing is more certain than that it has resulted in cutting down state sovereignty to make room for individual rights. Man's development has ever been an acquirement of rights against the state, and, in all political advancement, the state has consequently become less and less, and the citizen more and more. The progress of civil liberty has been from the beginning a wresting of power from despotic state sovereignty. Men fought early and desperately for the right of life—that is, that they should not have their heads cut off at the caprice of a sovereign will. They wrung from the state the right of the individual ownership of property. They reduced the functions of the state when it repressed free speech for its own sovereign purposes. They stripped the state of its power of determining what religion it thinks best for the community, and thus secured the rights of conscience. In all these things, and in many more, government has been restrained and hampered in its tyrannical meddlings, and the people have correspondingly gained in liberty. The state has always assumed that it knew more about what was good for the people than they knew themselves. What we call liberty is nothing more than the right of the people to be their own judges, and to manage their own concerns in the way that seems best for the promotion of their own interests. But Mr. Bryant interprets state sovereignty in a way that dissolves all individual rights. If the state may interfere at its

"sovereign discretion" to extirpate the family in the matter of education, if it may take away a child as soon as it is ready for the Kindergarten, and dictate the whole course of its cultivation, stamping its character with a view to state objects, what else may it not do, and what becomes of the vaunted freedom of the citizen? The doctrine belongs to despotism, and was first and fitly practiced in Prussia as a means of shaping subjects to the uses of kingly power.

And now what *is* the state that claims such prerogatives in virtue of its sovereignty, and proposes to take the education of the whole community into its own hands? Divested of the glamour that surrounds this venerable abstraction, that which remains of actual reality is simply a lot of men got together to carry on the practical work of government. The state lives in the life of its representatives. It exists only as embodied in its officials. Certain men are chosen to make, repeal, and execute the laws, and these are the state. The state can do whatever they can do; the state is whatever they are. But we are not yet down to the naked reality. The community is divided into two great political parties, and the one that beats by numbers at election takes the government. Successful office-seekers, therefore, constitute the state. Those who succeed in partisan politics are those who cultivate the art of partisan politics. What these arts are, and what is the general quality of those who win by them, we need not say. But it is notorious that men of intelligence, integrity, and character are not successful partisans. It is the intriguers, the wire-pullers, and the crafty, unscrupulous managers in caucus and convention that win, and these men form the state. We do not exaggerate: witness the last Legislature of our own State. Humiliating as it may be to our patriotic pride, every candid person knows it to be a fact that an election under our representative system, with its inevitable caucus and convention machinery, is simply a winnowing out of superior men and the choice of the worst to take the offices of state.

We need not dilate upon the consequences; they are known and read of all men, and the lesson they teach has been freely drawn. If any worthy or meritorious thing is to be done, the significant exclamation is, "In Heaven's name keep it out of politics!" Such, indeed, is the growing disgust with political doings that it is now quixotically proposed to take even office-holding out of politics. And, yet, there are those who would intrust our politicians —ignorant, self-seeking, unscrupulous, and corrupt as the great mass of them are—with the whole work of education in society. Who is so senseless as to look for educational progress in such a condition of things? The system will be turned to the purposes of demagogism as surely as effect follows cause. The management of institutions of learning will become an art of getting state appropriations. The educational system will become rigid in proportion to the extent and complexity of its gradations, and will resist all improvement. Teachers, inspectors, superintendents, become office-holders and stipendiaries under the Government, and all animated with the common purpose of getting their salaries increased. Education, as a function of the states, must become a branch of mercenary politics. And this system, by its vicious growth, and its prestige of authority, and the boundless means at its command, must rival and overcome and extinguish all that private and voluntary interest in the work of education to which we are indebted for the past achievements in this important field of effort. Good may come from state education, but it will not be unmixed good, and it is at least an open question whether the evils of the system, where it is fully

carried out, will not be far greater in the long-run than its benefits.

The many American friends of Mr. Herbert Spencer will be pleased to learn that he contemplates visiting this country next year. He has long wished to do so, but has been deterred from seriously thinking about it by the state of his health, which forbade the venture of an Atlantic voyage. But he is now so much better that this difficulty is removed, and he hopes to come over some time next summer.

LITERARY NOTICES.

The Bacteria. By Dr. Antoine Magnin, Translated by George M. Sternberg, M. D., Surgeon United States Army. Boston: Little & Brown. Pp. 227. Price, $2.50.

The readers of "The Popular Science Monthly" have been from time to time informed concerning the progress of inquiry in relation to those lowest, minute, and curious organisms now known under the general name of "Bacteria." The first observer who perceived them was the father of microscopy, the Dutchman Leeuwenhoek, as early as 1675. He was examining with his magnifying-glasses a drop of putrid water, when he remarked with profound astonishment that it contained a multitude of little globules which moved with agility. In 1773 they were studied by O. F. Müller, and classified as a group of the *Infusoria*. They soon began to occupy a good deal of the attention of microscopists, and there was much conflict of opinion about their nature, as was inevitable from the novelty of the research and the imperfection of instruments. At one time they were considered as animals, and at another they were taken for plants; were now ranked as *Algæ*, and again as fungi. But it is only in the present generation that our knowledge of them has become so perfect as to lead to a large amount of agreement among observers respecting their nature, varieties, and classification. It is now recognized that they are the lowest organisms, standing upon the limit of the two kingdoms, animal and vegetable, and are thus defined by the botanists who have most recently studied them: "Cells deprived of chlorophyl, of globular, oblong, or cylindrical form, sometimes sinuous and twisted, reproducing themselves exclusively by transverse division, living isolated or in cellular families, and having affinities which approach them to the *Algæ*, and especially to the *Oscillatoriæ*." There has been, as our readers are aware, a long and intense struggle over the question of their spontaneous generation, but the great preponderance of opinion is now against that mode of origin. They vary much in form and dimensions, but are regarded as the smallest of all microscopical beings. Some of them are motionless, but they are generally remarkable for the movements they exhibit. These are thus described by the eminent observer Cohn:

> In certain conditions they are excessively mobile; and, when they swarm in a drop of water, they present an attractive spectacle, similar to that of a swarm of gnats, or an ant-hill. The bacteria advance, swimming, then retreat without turning about, or even describe circular lines. At one time they advance with the rapidity of an arrow, at another they turn upon themselves like a top; sometimes they remain motionless for a long time, and then dart off like a flash. The long rod-bacteria twist their bodies in swimming, sometimes slowly, sometimes with address and agility, as if they tried to force for themselves a passage through obstacles. It is thus that the fish seeks its way through aquatic plants. They remain sometimes quiet, as if to repose an instant: suddenly the little rod commences to oscillate, and then to swim briskly backward, to again throw itself forward some instants after. All of these movements are accompanied by a second movement analogous to that of a screw which moves in a nut. When the vibrios, in the shape of a gimlet, turn rapidly round their axis, they produce a singular illusion: one would believe that they twisted like an eel, although they are extremely rigid.

An order of beings so amazingly minute that the various kinds of them are just barely revealed by the utmost powers of the microscope, might seem of little importance, at least, practically, in this world's concerns. But this is not so. The bacteria are at the foundations of life, and it is now admitted that they have a grand office in relation to the general preservation and continuance of life. Exactly in what way is perhaps not yet determined; but they are in some way

essential to the carrying on of vital organic changes. Dr. Magnin says, in his introduction: "It is known that organic matter once produced, and become solid, so to speak, can not again enter into the general current until it has undergone new transformations—metamorphosis *produced* according to some, *favored*, according to others, but without contradiction *accompanied* by the development of bacteria. And without wishing to attribute to these organisms a finality which is repugnant to our monistic conception of the universe, it may be said that it is, thanks to them, that the continuance of life is possible on the surface of the globe."

But the interest of these organisms is still more marked in practical directions. Their germs are in the air; they are distributed in the waters; and they swarm and propagate with astonishing profusion in organic liquids and infusions. They are involved in the processes of fermentation and putrefaction, and they have a *rôle* in the operation of violent diseases, such as variola, scarlatina, measles, diphtheria, typhoid fever, etc.; while their agency in connection with wounds gives them the highest interest to the surgeon.

It was therefore a capital service to science that was performed by Dr. Magnin in the preparation of this careful and complete book on the general subject at the present time. His volume is an ample report on the present state of what may be called bacterial knowledge. It is accompanied by faithfully executed plates and photographs, and contains, furthermore, an elaborate and exhaustive bibliography of the subject.

As a further illustration of the practical interest of the investigation here digested, it may be stated that Dr. Sternberg was led to translate it in consequence of its value in carrying on the work of the National Board of Health, the phenomena being vitally connected with various problems of public hygiene. The work has claims upon the scientific naturalist, the physician, and the non-professional man of general culture.

Life of Voltaire. By James Parton. In two volumes. Boston: Houghton, Mifflin & Co. Pp. 1,292. Price, $6.00.

Mr. Parton has been for many years a critical and deeply interested student of Voltaire and his times, and he has now given us the fruit of his studies in these two most entertaining and instructive volumes. Of Mr. Parton's large experience as a biographer, and his proficiency in the art, it is unnecessary to speak. He has had a lifelong preparation in this branch of literature, and now, in the maturity of his powers, he has produced a comprehensive work, that will enhance his reputation, and undoubtedly prove a valuable and prominent acquisition to our biographical literature. There was greatly needed a good life of Voltaire, both on account of the great historic interest of his personality, his profound influence upon his age, and the mass of prejudice and misrepresentation that has been piled upon his memory during the last hundred years. The task of clearing away the errors, and arriving at such truth as the circumstances allow, has been performed conscientiously by Mr. Parton with unsparing labor, and, so far as we can judge, with eminent success. He has made exactly such a book as we wanted ourselves, and we believe it will adequately meet an extensive need among American readers.

We note that some exceptions have been taken to the work by English critics, who write about it in a somewhat disparaging tone; and, perhaps, some reference to their treatment of it may be helpful in judging of its real merits. But it is necessary to bear in mind the nature and difficulties of the task which Mr. Parton had before him, and these can not be better stated than in his own prefatory words. He says:

> I attempt in these volumes to exhibit to the American people the most extraordinary of Frenchmen, and one of the most extraordinary of human beings.
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> When first I ventured, many years ago, to think of this task, I soon ceased to wonder why a subject so alluring had not been undertaken before by any one employing the whole of the existing material. Voltaire was then buried under a mountain of heterogeneous record. The attempts of essayists, even those of the first rank, to characterize him truly, were in some degree frustrated by an abundance of unsorted information that defied all ordinary research. Since that time the Voltairean material has continued to accumulate, and never so rapidly as during the last three years.
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> At this moment, if I lift my eyes from the desk on which I write, I see before me volumes containing fifty thousand printed pages of his composition, including more than two hundred and sixty separate publications. The published

correspondence of Voltaire now comprises more than ten thousand letters. The works relating to him and his doings form a catalogue of four hundred and twenty-eight entries, which will probably be increased before these volumes see the light. Scarcely a month passes without some addition to the wonderful mass. At one time it is a series of letters found in a grocer's shop, or rendered accessible by the death of an heir of one of his princely correspondents; now, an enterprising editor gives his readers an unpublished poem; recently, Mr. Gallatin deposited in the library of the New York Historical Society sixty-six pieces of paper and card containing words written or dictated by him; and in September, 1880, came from Paris the announcement of "Le Sottisier de Voltaire," from one of the eighteen volumes of manuscript in his library at Petersburg. No sooner is an edition of his works published, than it is made incomplete by a new discovery. Since the issue of the ninety-seven-volume edition in 1834, enough matter has accumulated to fill six or seven volumes more.

Still more strange, the mass of his writings, and I may even say every page of them, has to this hour a certain vitality and interest. If it has not intrinsic excellence, it possesses the interest of an obsolete kind of agreeable folly; if it is not truth, it is a record of error that instructs or amuses. He was mistaken in supposing that no man could go to posterity laden with so much baggage. In some cases it is the baggage that floats him, and many readers of today find his prefaces, notes, and introductions more entertaining than the work hidden in the midst of them. Nearly every page of this printed matter contains at least an atom of biography, and I can fairly claim to have had my eye upon it, indexed it, and given it consideration.

The reader is probably aware that every circumstance in the history of this man, from the date of his birth to the resting-place of his bones, is matter of controversy. If I had paused to state the various versions of each event and the interpretations put upon each action, this work would have been ten volumes instead of two. It would have been, like many other biographies, not a history of the man, but a history of the struggles of the author in getting at the man. Generally, therefore, I have given only the obvious or most probable truth, and have often refrained from even mentioning anecdotes and statements that I knew to be groundless. Why prolong the life of a falsehood merely for the sake of refuting it?

The Voltaire of these volumes is the nearest to the true one that I have been able to gather and construct. I think the man is to be found in these pages delineated by himself. But he was such an enormous personage, that another writer, equally intent upon truth, could find in the mass of his remains quite another Voltaire.

Now, it is obvious enough from these statements that the work of sifting materials and discussing minutiæ in regard to Voltaire, his multitude of works, and the interminable comment thereon, might have no end. Its perfection, according to the ideals of a pedantic scholarship, is impossible. Numberless details must remain for ever unsettled, and there would remain room for charges of error, no matter how far investigation was pushed. Mr. Parton is the last man who will claim that his treatment of the subject is infallible, but he may justly claim that he has gone as far as fair criticism can demand, toward making his book accurate and trustworthy. Mr. George Saintsbury, who has the reputation of being "one of the highest English authorities on French literature," reviewing Mr. Parton's work in "The Academy," recognizes that Mr. Parton is no "mere book-maker," but a "perfectly honest writer, and appears to have digested his enormous materials with a great deal of diligent effort"; but he thinks he has failed in producing "a work of art and an independent contribution to literature." And what is the evidence of this? Why, that "an innumerable multitude of small errors disfigures his pages." Mr. Saintsbury read the first 250 pages of Mr. Parton's book in careful search of defects, and says that he finds on the margins no less than fifty-four black marks, indicating what he deems imperfections. Some are awkwardnesses of expression, some excusable slips, some inept observations, some critical mistakes, and some actual errors. The examples he gives show the triviality of the blemishes he has marked, and they are mainly of a sort which could never be perfectly eliminated from a performance of this kind. Mr. Saintsbury objects that Parton's biography is not a "work of art," but works of art appeal to the taste, and tastes differ. Mr. Saintsbury comes to his work of criticism as "one of the highest English authorities on French literature." He is an adept in Voltairean studies, and in the first half of a large volume he finds fifty-four petty flaws, some of which are differences of opinion, and some, no doubt, real faults. We want no better evidence of the general ability and fidelity of the work than that a master of the subject can find no more to say against it than is stated in this criticism of "The Academy."

Marine Algæ of New England and Adjacent Coast. By Professor W. S. Farlow. Reprinted from the Report of the United States Fish Commission for 1879. By George A. Bates. Salem, Massachusetts. Price, $1.50.

Since the publication, by the Smithsonian Institution, nearly twenty-five years ago, of Harvey's "Nereis Boreali-Americana," there has been no work on United States algæ, except formal lists, to which the student could refer. Dr. Farlow, who is one of the most eminent algologists in the country, has given us in this work a compact hand-book which will be of great service to the collector and student. In the introduction much interesting information is given regarding the distribution of species along the coast. Cape Cod forms a barrier to many species. Dr. Farlow says the difference between the flora of Massachusetts Bay and Buzzard's Bay, which are only a few miles apart, is greater than the difference between those of Massachusetts Bay and the Bay of Fundy. This difference is found to correspond precisely with what is known of the fauna. He speaks of the occurrence of southern species of sea-weeds in a small sheet of water near Gloucester, to which the sea has access during a small portion of each tide, and, in referring to the presence of certain northern species south, says, "It seems to be the rule that wherever the water is cold enough we meet Arctic species, and wherever it is warm enough we have Long Island species, regardless of the remoteness of localities where the species naturally abound, and, as far as we know, of the absence of currents to transport the spores." The book closes with an excellent bibliography, and fifteen plates containing fifty-seven figures.

Hand-book of Chemical Physiology and Pathology, with Lectures upon Normal and Abnormal Urine. By Victor C. Vaughan, M. D., Ph. D., Lecturer on Medical Chemistry in the University of Michigan. Ann Arbor Printing and Publishing Co. Pp. 347.

The second edition of this work was called for in 1879, the first having been speedily exhausted. A third edition, revised and enlarged, appeared last year. The nature of the work is expressed in its title. It makes no claim to completeness, but is offered as a guide to the student who desires to pursue this branch of study. The latest authorities have been followed, and free use has been made of standard works and journals treating upon the various subjects discussed. In the present edition there is appended a second part, consisting of finely executed plates for illustration of the text. The book may be commended as giving within reasonable limits an excellent account of chemical physiology and pathology.

"English Philosophers, David Hartley and James Mill." By Mr. G. S. Bower, M. A. New York: G. P. Putnam's Sons. Pp. 250. Price, $1.25.

The reason why these authors are reviewed in company is probably because James Mill's system forms a sort of sequence to Hartley's, although this sequence is manifestly due more to the incidents of general intellectual growth in England than to any relation of discipleship between the authors.

The doctrine of association is shown to have first received a definite form at the hands of Hartley, although its inception as a principle is traced as far back as Aristotle. James Mill elaborated this doctrine, having at his command richer stores of science, but deprived it of some of those wider applications which later writers have adduced, and which were foreshadowed by the superior imagination of Hartley. To quote the author: "Let us first find a statement of the doctrine of association, in its very simplest terms. So far Hartley and James Mill are perfectly at one. We will take the definition given by the latter. 'Our ideas,' he says, 'spring up, or exist, in the order in which the sensations existed of which they are copies. This is the general law of the association of ideas, by which term, let it be remembered, nothing is here meant to be expressed but the order of occurrence.'"

On the whole, Hartley's conception of the doctrine was more physical than Mill's. He called it a theory of vibrations. The counterpart and development of this theory of vibrations, as explained by Hartley, is to be found, the author tells us, in the "neural tremors" described by G. H. Lewes and Dr. Maudsley.

A very simple and, perhaps, more ad-

vanced view of it might be expressed as follows: If all the physical forces are but affections of matter, quivering particles of the medium affected, it is easy to see that the senses, which we find to be special adjustments of ourselves to these different forces, are merely channels of different kinds of motion leading to the brain. In a word, therefore, the sensation of light is a definite motion of a definite part of the brain. If it were possible to study the lines or areas of motion which a sensation of a given intensity sets up in the brain, or the structural changes which accompany the repetition and combining of different sensations, there would be some hope that the physical or subjective aspect of the law of association could be explained. The difference between the apprehensions of this law by Hartley and Mill is that Hartley, being a physiologist, and moved by the excitement of discovery, endeavored to portray the subjective aspect of this law, while Mill devoted himself to its manifestations in the relations and history of life.

The author has made a great many selections from these two writers, which has the effect of bringing their systems into view side by side. He precedes these selections with a biographical sketch of Hartley and Mill, and accompanies them with comparisons and criticisms of his own, which constitute the greater part of the book. The value of such a book depends, of course, upon the point of view from which the criticisms are made, and the skill of the selections. With regard to the latter, but little improvement could be suggested, and, although some opportunities have been neglected of bringing important points into bold relief, the criticisms are remarkably just and free from error.

Text-book of Experimental Organic Chemistry for Students. By H. Chapman Jones. New York: D. Van Nostrand. Pp. 145.

The author of this book has added another to the already considerable list of useful little manuals on practical chemistry. He confines himself to organic chemistry and has endeavored to make the study of that branch of science more interesting to the quite elementary student than has been done by previous authors. The work is not a text-book, but merely a laboratory companion for the student, and is, moreover, especially arranged for those who have but a limited time at their command. It is not illustrated, though a good number of simple experiments are described.

The Botanical Collector's Hand-book. By Professor W. Whitman Bailey. Naturalists' Handy Series, No. 3. Salem, Massachusetts: George A. Bates.

This is precisely what its name implies. The contents are arranged under the general headings of Herborizing, Field-Work, Collecting and preserving Fungi, Closet-Work, The Herbarium, Bibliography, Herbaria, and Public Herbaria.

Under each of these headings much valuable information for the collector is given.

PUBLICATIONS RECEIVED.

The Epidermal Organs of Plants: Their Morphology and Physiology. By Charles F. Cox, F. R. M. S. Pp. 15.

A Report on the Teaching of Chemistry and Physics in the United States. By Frank Wigglesworth Clarke, S. B., United States Bureau of Education. Pp. 219.

"The Tonic Sol-Fa Advocate." Edited by Theodore F. Seward. Vol. I, No. 1. New York: Biglow & Main. Monthly. Pp. 16. 50 cts. a year.

Annual Report of the Board of Directors of the Chicago Astronomical Society, together with the Report of the Director of Dearborn Observatory. 1881. Pp. 16.

Descriptions of some New Tortricidæ (Leaf-rollers). By C. V. Riley, M. A., Ph. D. Washington. Pp. 9.

Some Double and Triple Oxalates containing Chromium. By F. W. Clarke. The Titration of Tartaric, Malic, and Citric Acids, with Potassium Permanganate. Preliminary Note. By F. W. Clarke. Pp. 7.

Pliocene Man in America. By James C. Southall, A. M., LL. D., of Richmond, Virginia. New York: A. D. F. Randolph & Co. Pp. 30.

Braithwaite's Retrospect of Practical Medicine and Surgery. Part lxxxiii. New York: W. A. Townsend. Pp. 276.

What shall We do with the Inebriate? By T. D. Crothers, M. D. Hartford, Connecticut. Pp. 24.

Hip-Injuries, including Hip-Joint Disease, and Fractures of the Femoral Neck: Splint for. By De F. Willard, M. D. Philadelphia. Pp. 4.

Hip-Joint Disease; Death in Early Stage from Tubercular Meningitis. By De Forest Willard, M. D. Microscopic Appearances, with Cuts. By E. O Shakespeare, M. D. Cambridge: Riverside Press. Pp. 20.

Fifth Annual Report of the State Board of Health of Wisconsin. 1881. Madison, Wisconsin. Pp. 156.

Catalogue of the Phænogamous and Vascular Cryptogamous Plants of Michigan, Indigenous, Naturalized, and Adventive. By Charles

F. Wheeler and Erwin F. Smith. Hubbardstown, Michigan. Pp. 105. 50 cents.

The Mineral Resources of the Hocking Valley: Being an Account of its Coals, Iron-Ores, Blast-Furnaces, and Railroads. By T. Sterry Hunt, LL. D. Boston: S. E. Cassino. Pp. 152, with Map. 75 cents.

Educational Journalism. By C. W. Bardeen. Syracuse, New York. Pp. 30.

The Physiology of Climate, Season, and Ordinary Weather Changes. By Alexander Rattray, M. D. San Francisco, California. Pp. 20.

"The Odontographic Journal: A Quarterly devoted to Dentistry." Conducted by J. Edward Line, D. D. S. Rochester, New York: Davis & Leyden. Pp. 64. $1 a year.

Proceedings of the United States National Museum, June 2 and 22, 1881. Pp. 80.

A Manual of Accidents and Emergencies. By George G. Graff, M. D. Lewisburg, Pennsylvania: Printed for the Author. 1881. Pp. 92. 50 cents.

Revised Odd-Fellowship illustrated. By President J. Blanchard, of Wheaton College. Chicago: Ezra Cook & Co. 1881. Pp. 272. $1.

The French Revolution. By Hippolyte Adolphe Taine. Translated by John Durand. Vol. II. New York: Henry Holt & Co. 1881. Pp. 358. $2.50.

Annual Report of the Chief Signal Officer to the Secretary of War, for the Year 1879. Washington: Government Printing-Office. 1880. Pp. 782.

Algebra for Schools and Colleges. By Simon Newcomb. New York: Henry Holt & Co. 1881. Pp. 454.

The Young Folks' Astronomy. By John D. Champlin, Jr. New York: Henry Holt & Co. 1881. Pp. 236. 60 cents.

Sea-Mosses. An Introduction to the Study of Marine Algæ. By A. B. Harvey, A. M. Boston: S. E. Cassino. 1881. Pp. 281. $2.

Book of the Black Bass. By James A. Henshall, M. D. Cincinnati; Robert Clarke & Co. 1881. Pp. 470. $3.

POPULAR MISCELLANY.

Science in Politics.—"Science and Civil Liberty" was the subject of an address by Dr. W. R. Condell at a recent meeting of the Scientific Academy of Springfield, Illinois. Its object was to show the important bearing of the physical sciences on political science, and their claim to be regarded in suggesting and instituting reforms. Accepting Mr. Spencer's principle that the social aggregate must be determined by the units composing it, he derived the corollary that any social or political system, arbitrary in its nature, and not determined by the nature of the units, must be disastrous to the units or individual citizens. The scientific study of the mind from the physical side must have an important bearing upon the subject of crime as well as on other social questions which have never been solved by existing methods. The metaphysical school, whose deductions rested on a less solid basis than the hard facts of nature, had had too much influence in our legislation. Science, Dr. Condell believed, should be acknowledged as the supreme political standard; and not till this result had been consummated would perfect civil liberty be realized.

Somnambulism. — The phenomena of somnambulism arise from the fact that the faculties are unequally suspended during sleep, so that one set of organs may be active while the others are dormant. It is frequently accompanied by dreams, which arise out of a similar condition of the nervous functions. Several incidents, illustrating the manner in which the partial suspension, partial activity of the faculties affect the somnambulist, are related in an English magazine. A boy, on his way to the seaside, had traveled by steamer, railway, and coach, from six o'clock in the evening till four o'clock on the next afternoon, without cessation and with hardly any sleep. Shortly after going to bed, his companion was awakened by a crash of glass, followed by hysterical cries, and, on looking for the boy, found that he had got up, broken the window, and gone. He was found in the road, wounded in the feet. It appeared from his story that, when half asleep, he thought he saw a mad bull rushing at him. Catching hold of the curtain, which he thought was a tree, he swung himself over the hedge by which the tree grew—the window, open from the top—then jumped and ran away, breaking the window with his heel, and cutting his feet on the sharp stones. In this case the impression left on the mind of the sleep-walker was so strong as to enable him to tell all that he thought and imagined during the dream. In the next incident no trace of remembrance survived. A servant-girl came down at four o'clock in the morning, and asked her mistress for some cotton to mend her dress, which she had torn. While she was looking in her work-box some one offered her an empty spool, but she refused it, and taking up her gown pointed to two holes which she said she wanted to mend. A needle was threaded for her with black cotton, but she rejected it, saying she wanted brown cotton. Some one spoke, and she

said that it was her mistress; but it was not. Her vision was thus shown to be keen, but her hearing dull. She was wakened with considerable difficulty, and, seeing the cotton-box disturbed, asked why it had been meddled with. Several questions were asked her during the following day, to test her recollection; but she could not recall her sleep-walking, or anything that had taken place during the night. A miner near Redruth arose one night, walked to the engine-shaft of the mine, and safely descended to the depth of twenty fathoms, where he was found soon afterward sound asleep. He could not be wakened by calling to him, and had to be shaken. When awake, he could not account for the situation in which he found himself. Morrison, in his "Medicine no Mystery," tells of a clergyman who used to get up in the night, light his candle, write sermons, correct them with interlineations, and go to bed again, while he was all the time fast asleep. A similar story is told of an English dissenting preacher, who had been perplexed during the week about the treatment of the subject of his Sunday's sermon, and mentioned his perplexity to his wife on Saturday night. During the night he got up and preached a good sermon on the subject in the hearing of his wife. In the morning his wife suggested a method of treating the subject, based upon his sleep-work of the night before, with which he was much pleased; and he preached the sermon with no knowledge of its real origin. The "Lancet" has a story of a butcher's boy who went to the stable in his sleep to saddle his horse and go his rounds. Not finding the saddle in its usual place, he went to the house and asked for it, and, failing to get it, he started off without it. He was taken from the horse and carried into the house. A doctor came, and while he was present the boy, considering himself stopped at the turnpike-gate, offered sixpence for the toll, and this being given back to him he refused it, and demanded his change. A part of the change was given him, and he demanded the proper amount. When awake afterward, he had no recollection of what had passed. To prevent sleep-walking it is necessary to remove whatever is the occasion of it, if it arises from any definable disorder. Often, however, it can not be referred to any complaint; then the best that can be done will be to take precautions against the somnambulist running into any danger.

Parasites in Food and Drink. — M. Milne-Edwards has recently expressed some interesting views suggested by the discussions concerning trichina, respecting the hygienic questions which are connected with the establishment of colonies of intestinal worms, or *microbes*, within human bodies. He believes that certain religious precepts and certain established usages, among people whose civilization is very ancient, are based upon acquaintance with the inconveniences that may result from the alimentary use of particular meats or waters. He thus deduces, from the aptitude of the hog to transmit his parasites to man, the reason for the prohibition of pork among the Israelites and Mohammedans, and for the Biblical distinction between pure and impure animals. He also attributes to the very ancient recognition of analogous facts the general use of hot drinks, like tea in China and other countries of the extreme East, where the natural waters are often charged with noxious animalcules or polluted by unclean animals. As bearing on this point, he cites the ravages caused in Cochin-China by a microscopic eel, which produces a persistent endemic diarrhœa. These animals have a faculty of multiplication in the human intestine, that is illustrated by the fact that a single patient is said to have evacuated more than a hundred thousand of them within twenty-four hours! The simplest prudence should suggest the expediency of boiling the drinking-water wherever they abound.

The Great Vienna Telescope. — The equatorial telescope which has just been constructed by Mr. Grubb, of Dublin, for the observatory at Vienna, Austria, is the largest refracting telescope that has yet been made. It has an aperture of twenty-seven inches, or one inch more than that of the instrument in the Naval Observatory at Washington, and is thirty-three feet six inches long, with a tube of steel three and a half feet in diameter in the middle, and tapering to each end. The moving parts,

including the tube, polar and declination axes, counterpoise, and various adjustments, weigh altogether between six and seven tons, yet the whole apparatus is under such control that one person can move it about and manipulate it with ease. The motion on the axes has been facilitated by the application of antifriction apparatus to them, so that it has not been necessary to make them disproportionately small, as has been the case with the axes of previous large instruments. The circles are carefully and accurately divided on a band of gold, and so adjusted and illuminated that the observer can, without stirring from his chair, read all of the circles of the instrument through a single reader-telescope attached to the side of the main tube. The builder of the instrument had great difficulty in obtaining perfect glass for the objectives, and more than a year, from October, 1879, to December, 1880, was spent in trying to produce a good lens; nevertheless the instrument was completed in less than half the time stipulated for by the Austro-Hungarian Government. The observatory in which the telescope is to be placed is an imposing edifice of three hundred and forty by two hundred and forty feet, and stands at an elevation of two hundred feet above the city, upon grounds of between fifteen and sixteen acres in extent.

The Cave-Temples of India.—Dr. James Fergusson's recent work on the "Cave-Temples of India" abounds in illustrations of the manner in which the art of building in stone has been developed from wooden construction. The beginning of the use of stone in India is fixed, in Dr. Fergusson's opinion, at the period of the reign of Asoka, B. C. 250, for no stone buildings of an architectural character have been found the date of which can be proved to be earlier than that of this monarch. Moreover, all the older examples are, in all their details, so clearly copies of original types in wood, that it is improbable that they could have been executed by a people who had any previous knowledge of the principles of stone architecture. All caves, down to the seventh century, show the gradual transformation from wooden forms into those of stone. The modifications may be traced onward through nine centuries—all that was of stone being copied literally from carpentry forms, till the process was nearly complete, and forms, originally distinctly wooden, had become appropriated to stone architecture. All this seems to have been effected without any direct foreign influence. The earlier caves are adorned with sculptures in preference to painted figures, but the later ones are covered with paintings of a high order of art and great historical interest, with colors perfectly fresh, while sculpture, where it occurs at all, occupies a subordinate position. No figure of Buddha occurs before the end of the first century. The liturgical forms, in all the older caves, express a simple but exclusive type of relic-worship. About one thousand distinct caves in India are mentioned as having architectural importance, of which three fourths belong to the Buddhists, one fifth to the Brahmans, and five per cent. to the Jains. The Buddhist caves are the oldest and the most interesting. They are all true caves, excavated at right angles to the face of the rock in which they are formed, with designs appropriate to their situation in it. The caves of the Brahmans are often copies of structures whose outlines have no reference to the position in which they are placed, or the material out of which they are carved. The Buddhist caves seem to have been gradually developed from single plain cells cut into the rock, the dwelling of a single anchorite, into groups of eighteen or twenty cells, arranged around a hall sixty or seventy feet square, the roof of which was supported by pillars elaborately carved, the whole forming a *vihara* or monastery. Such caves are usually found grouped together, five or ten, and even fifty or sixty in immediate juxtaposition, so as to form an establishment capable of accommodating a large number of monks. To each of the groups was attached one or more *chaityas* or "church-caves," as they might be called, which were analogous in form and use to the choirs in Christian churches. The finest of these is that of Carlee, near Poonah.

Lunar "Craters."—M. Faye recently delivered a lecture at the Sorbonne, on the volcanoes of the moon, the substance of which was an essay to show that there are

no volcanoes in the moon. Volcanic action can only take place where water is present. The moon having no water, the idea of such action there is precluded. M. Faye supposes that the so-called "craters" of the moon were formed, not by erruptive action, but by the action of the fused mass of the interior upon the crust, after it had begun to solidify. The liquid mass was subject to tides, which, surging against the crust under the influence of the earth's attraction, washed holes in it, when the fluid rose above it, and formed ridges around the holes, in the same way as the tidal waters of the sea act upon shore-ice. The ridges thus left formed the rings or circles of the "craters." The continuing solidification of the fused matter finally caused a formation of a bottom to the crater. Sometimes the bottom, not yet firm, would yield to the pressure of the molten mass beneath it, which, rising through it again, left the central hills which are remarked in some of the circles. M. Faye does not deny that water may have once existed in the moon, and have been finally absorbed in the solid matter, but he asserts that it could never have existed in the shape of seas, or in such quantities as to occasion volcanic action. If it had so existed, evidence of its action on the land would still be visible; but no feature of the moon's surface exhibits an appearance attributable to any known action of water. The appearance of the craters is, moreover, not like that given by terrestrial volcanic action, but is that which would be given by the agency M. Faye supposes.

Arrow-Poison of the South-Sea Islands.—Herr Weisser, of the German war-ship Ariadne, has obtained from a Christianized native of the South-Sea Islands a description of the preparation of the poisoned arrows and spears of his people. It is a matter of intricate processes, and is the peculiar business of a class who possess the secret. The spear and arrow heads are made from the arm and leg bones of persons who, having died of acute diseases, have been buried for five or six months. The spear-heads are made of the larger bones of the leg, to which the shaft, inserted in the hollow, is bound with a string of bark. The other bones are sawed with an instrument made from the spines of an echinus into pieces an inch or two long, and ground down to a fine point for arrow-heads. The poison is prepared from several plants, three of which are almost invariably used. The most poisonous of them is the *toto*, a large tree, bearing handsome white flowers and a red, almond-like nut, the juice of which, sprinkled into the eyes, produces blindness, taken internally, death, and which seems to be allied to the spurges. Another plant, called *pulu*, is of the family of the dog-banes; and the third plant, called *nasola* and *fanuamamala*, is another spurge, represented in Samoa by three species. The leaves of these trees, stripped of their stems and points and dried, are pulverized; a powder of the scrapings of old weapons is added; the mass is wrapped up with a sea-worm (*holothuria*) in a leaf of *colocassia*. The foul liquid which results from the dissolution is thickened with more of the powder into a thin paste; earth gathered from the neighborhood of a wasps'-nest, and pulverized with a thigh-bone, is put in; the mixture, having been dried in the sun, is treated with the oil of an old cocoanut; a dark, cloudy oil is formed after a month of manipulation, and this is put away for a year till it becomes of the consistency of fat, when the poison is considered ready for use. The spear and arrow heads are smoked in a furnace prepared for the purpose with a particular wood. The manipulator takes a small portion of the poison, rubs it carefully upon the arrow-head, and again smokes the latter. The prepared heads are wrapped in the dried flower-stalk of a tacca-plant, and are then put in a quiver made of the cylindrical stems of the banana, and hung over the fire to dry, for dampness spoils the preparation. The poison is fatal if taken internally, but no man ever thinks of revenging himself on his enemy by administering it to him. Women, however, are said sometimes to rid themselves of an unloved husband in this way. The effect of wounds by the poisoned spears and arrows is ordinarily great local pain, followed by general disturbance of the system, ending in a few days in convulsions, lockjaw, and death. Sometimes, if the wound is cut out immediately, the patient recovers; at others, the disease assumes a more gradual form, but ends

quite as malignantly. Lockjaw appears in every fatal case. Some men pretend to be acquainted with antidotes, but their first care on being called to a patient is to remove everything that might excite him to convulsions. The father of the native who furnishes the description of the poison assured him that he had been often wounded, and had averted the evil effects by cutting himself in different parts, so as to draw away the poisoned blood.

The Secular Changes of Level in the Earth's Crust. — Professor Suesz, author of a work on the "Origin of the Alps," recently delivered an important address before the Geological Institute at Vienna, on the fundamental causes of the repeated changes which have taken place in the distribution of land and water on the globe. He assumed that, as viewed in the light of more recent observations, the question did not concern apparent elevations or depressions of land within particular spaces, but dealt with an increasing prominence of the whole northern polar cap of the earth, far down into the temperate zone, effecting a real change in the form of the planet. Howorth, who thought he had detected an elevation of the land toward both poles, and a depression near the equator, concluded that the solid part of the earth was steadily suffering a contraction in the equatorial regions, and becoming projected toward the magnetic poles. Robert Chambers, in England, forty years ago, and Domeyko, in Chili, inferred from the repeated occurrence of terraces, apparently showing that the land had risen, that a force was at work changing levels which embraced the whole planet; and, in later times, many who have studied the subject most thoroughly, as Pettersen, have not repressed their doubts of the sufficiency of the common theory of elevations to account for the phenomena which they have observed. Many have been led, from the force of these facts, to embrace the theory of Adhemars and his followers, Croll and Schmick, that accumulations of great masses of water take place alternately around one and the other pole; but the presumption of alternation is contradicted by the fact that terrace-formations occur along the coasts of South America, South Africa, and Southern Australia, which seem to be as remarkable and as regular in their distribution as those which have been observed in the northern hemisphere. In order to be accurate in expression, Professor Suesz does not speak of elevations or depressions either of the land or the sea, but of displacements of the coast-lines; of negative movements when the result is an apparent elevation, positive movements when it is an apparent depression of the land. Using these forms of expression, the height of the upper level of a series of terraces does not represent a measure of the rising of the land, but the amount by which the sum of the negative movements of the shore-line since the time when it was at its highest level is greater than the sum of the positive movements. That repeated changes from one movement to the other are the rule is shown by the step-like form of the coasts at points where many traces of them have been left, as at Van Rensselaer Harbor, Port Ffoulke, and Cape York, in the Arctic regions. Sometimes they so balance each other that the coast-line is substantially stationary for a long time, when a steep cleft in the rocks is formed, as above Montreal and at the Island of Tromsoe. We know nothing of the laws that govern these oscillations. Many of the comparisons of level hitherto made have been liable to error, arising from regarding the partly compensated sum of the several movements in one place and the latest observed movements in another place as of equivalent value. Many examples show that a positive movement has taken place on the coast of Europe within historical times, reaching at Naples to the holes in the pillars of the temple of Serapis at Puzzuoli; at a later period, perhaps between the fifth and ninth centuries, a negative movement began, of which we can not definitely say whether it still continues or not. The oscillatory character of the changes can hardly be comprehended from the point of view of a movement of the solid part of the earth's crust; it might rather be compared to the breath of a living body. Some investigators, as Charles Darwin and Kjerulf, have adopted the theory of interrupted or rhapsodical elevations, instead of the old one of symmetrical oscillations; but

the extent of the terraced shores shows that this view is erroneous. Such shores have been found everywhere in high northern latitudes, so far as their wastes have been penetrated. They are also extensively found, but generally diminishing in height, down in the temperate latitudes. In other words, around the north pole, and far down toward the south, the sum of the negative movements of the coast-lines is greater than the sum of the positive movements, but the sums become more nearly equal as we come south. The opposite is the case in the tropical waters, in the regions of the coral reefs, where the sum of the positive movements is in excess. Farther to the south, beyond the twenty-fifth to the thirty-fifth parallels of latitude, there begin again to appear, in South America, in South Africa, Southern Australia, and New Zealand, terraced lands like those of the north, the same excess of negative movements, the same signs of oscillation, as in the north. The gradual tendency to a higher exposure of the land toward both poles has been noticed in single large tracts by many observers in North America, in England, Scotland, Scandinavia, China, Australia, and South America. When we consider as a whole the character and extent of these movements, as recent observations have defined them, and regard the compensatory results of the excess of positive movements toward the equatorial regions, and of the negative movements toward the neighborhood of the poles, we shall be convinced that we should no longer speak of an inexplicable oscillation of the lithosphere. We have, in fact, to do with continuous changes in the figure of the fluid covering of the earth. Since the epoch of the maximum of cold, which Hochstetter believes came upon both hemispheres at once, an excess of positive results has taken place in the direction of the poles, causing an accumulation of water around them, and this has been followed by an accumulation in opposite directions, or toward the quator, causing a change of form which is still going on.

Persian Opium.—The production of opium has greatly increased in Persia within the last two years, and the quality of the drug has been correspondingly improved. Previous to 1876 the average annual production was about 2,000 cases, and the largest return in one year did not exceed 2,600 cases. The amount for 1878–'79 was 6,700 cases, and the estimate for 1879–'80 is for 7,100 cases. Great care is now taken to prevent adulteration, but this does not appear to be always essential. Five sixths of the product is sent to China. For this market the drug must be fine and prepared in oil, but need not be rich in morphia. It can be largely swelled up with foreign substances, with but little danger of detection by the testing processes in use there. It is said that pure and superior opium, though not so finely manipulated, has been rejected in China, while the fine opium, containing admixtures, has found favor and a fair market. The preparations intended for England are made especially pure, and yield an average of about twelve per cent. of morphia, while those intended for China yield from nine to ten per cent.

Mortality in Different Pursuits.—The reports of the British Registrars-General show that the annual death-rate in the United Kingdom is about one in forty-five of the entire population. The larger, but not the largest, towns lead in the rate of mortality, and the rural mainland districts occupy an intermediate place between them and the insular districts, the extremes varying by about fifty per cent. As between the three great classes into which the population may be divided—the laboring, the trading and professional classes, and the gentry and titled—the chances of life are very nearly equal, although a slight advantage appears to be shown in favor of the first class. The trades most unfavorable to long life are, as a rule, those which tend to expose the operative to an atmosphere loaded with dust, or compel him to deal in one way or another with poisons. Dry grinding, as practiced on needles and forks at Sheffield, is the worst; working in coal-mines is next in deadliness. Gilders and silverers of glass are exposed to vapors of mercury; workers in brass are liable to diseases produced by exposure to volatilized oxide of lead; all who work in paints are subject to great risks; soldiers and sailors have their lives shortened by the exposure they have to undergo, or by diseases

brought on by their habits of living. Bakers, tailors, and milliners are liable to consumption; compositors peculiarly so. Pressmen fare better than compositors, probably because their work is more active. In the country, farming appears to be the most healthy of occupations, while that of the innkeeper is the most fatal. Butchers die comparatively early, as also do brewers, draymen, and generally those who have much to do with establishments for eating and drinking. The over-exertion of those who follow athletic pursuits appears to conduce quite as much to short life as does the sedentary strain of the student. It seems to make but little difference in the "expectation of life" of in-door workers whether their labor is hard or not; but those who are employed out-of-doors have a chance of living six years longer, if their work keeps them busy and active, than if it is a mere matter of routine and standing around; and a "comparison of the tables leads us to the conclusion that the life of the out-door worker with little exercise is worse than that of the sedentary in-door worker, whether with little or with great exercise." The most curious fact brought out is that the scavengers, dustmen, and cleaners of sewers in London are reckoned among the healthiest of the population.

Conditions of Color in Flowers.—The physiological processes of the coloring of flowers and the relations of different agencies, as light, temperature, the nature of the soil, and natural selection, are examined by F. Hildebrand in a work on the present variations and former development of the colors of flowers. The variations in the colors of flowers seem to be without limit, yet they are controlled by laws both in nature and in cultivation. Each kind has certain directions in which variations are more likely to take place, which are limited in extent, and are denoted by the colors which its congeners prefer. The character of the variations which any one species will take corresponds with the variation direction of other species of the genus, and can not be essentially changed by cultivation. All colors may be made to turn to white. Blue-blooming species may be made to vary to violet and red, but not, with the single exception of the blue hyacinth, to yellow. The variations of red-blooming species incline toward the colors of the nearest related species; if both yellow and blue kinds occur among the latter, the inclination is rather to the yellow tints, but a pure blue is never reached. Efforts have been made without success to produce blue pinks, zinnias, roses, hollyhocks, ranunculuses, primroses, and balsams. A yellow-blooming species will not vary to clear blue, even when there is a blue species in the same genus. Generally, the yellow-varying species belong to such genera as move in the red and yellow circle of colors, and the variations occur inside of this circle. The membrane of the plant-cells is nearly colorless. Colors arise either from the chlorophyl, the coloring-matter connected with the solid bodies within the cells, or through the coloring of the cell-juices, or by changes taking place in both the chlorophyl and the cell-juices. The red and orange colors are generally derived from the chlorophyl, as is exemplified by the fact that the red and orange masses in many flowers are frequently developed out of masses that were before green. The chorophyl is seldom replaced by a red or blue grainy matter. White is readily produced, for all that it requires is the absence of chlorophyl or its presence in only a limited quantity. Other colors are produced by the coloring of the cell-juices with other matter than chlorophyl. So originate the rose-red flowers, some of the fiery red, most of the violet and blue. If no coloring takes place, the flower is white; hence the abundance of white flowers, and their occurrence whenever a species is made to vary. If a change takes place in both parts, if the chlorophyl is modified and the cell-juice is colored too, mixed colors, both bright and dark or dusky ones, are produced. A bright red often becomes prominent in this way, which, when combined with yellow arising from the chlorophyl, gives such colors as we find in the canna and nasturtium. Dark colors are produced by the association of green or yellow grains of chlorophyl with a violet juice, as in the nightshade. We look for the origin of diversities of color to conditions of light, temperature, and soil, and to the operation of natural selection. Dif-

ferent plants require different degrees of light and heat for the formation of their colors. Ferns and conifers need but little. Different colors require different degrees for their development; yellow is an exception, for it seems to be found equally well under the most varied circumstances. Some red flowers, as the tulips, color well in the dark, and the blues and violets seem partly independent partly dependent on the light. The crocus takes on its deep-blue violet in the dark, while the *Prunella grandiflora* remains white. A steady supply of nutriment is essential. Askenasy tried some cut branches of foxglove and other plants in a glass exposed to a strong light. The first flowers that came out were bright, but the others grew paler, and the last were nearly white. The failure of nourishment neutralized the stimulating effect of a strong light. The effect of these external agencies is dependent on the disposition of the flower to particular colors. They may aid the tendency, but do not perceptibly modify it. The supposition that particular seasons are favorable to the development of particular colors is not fully established; and the real amount and extent of the influence of changes of season on color is not ascertained. The investigation of the effect of the soil is attended with great difficulties. When we change the soil, we change other relations, as those of light and temperature, without being able to measure the part that each may have in producing the result we see. By introducing changes in all the conditions we cause an abrupt modification in the life of the plant, by which it becomes more docile to our treatment. Hence most of the variations take place under cultivation. Variation once started, further changes are comparatively easy. Natural selection operates to perpetuate variations. Those colors which stand out most distinct from the surrounding green attract the insects which act as fertilizing agents, and become predominant and permanent.

A Fortress of the Polished-Stone Age in Spain.—M. A. F. Nogués, mining engineer, gives in "La Nature" an account of a fortified camp of the polished-stone age, situated on the plateau of Maestrazgo, Spain, which was discovered by the Abbé Ambrosio Sans, and which he has recently visited. The work is situated on the elevation called the Muela de Chert, which constitutes the highest groups of hills of the plateau, rising 2,880 feet above the sea. The end of the plateau shows a steep limestone ledge inaccessible at almost every point. At a considerable distance from this point, the lines of the fort are marked by an irregularly disposed mass of weather-browned stones running across the ridge which is the continuation of the Muela, and separating the higher parts of the eminence from the lower levels of the plateau. A real fortified inclosure is thus formed, defended on one side by the natural precipitous escarpment, and by the wall along the rest of the circuit. The curved part of the wall, for a length of about eight hundred feet, is built of stones without mortar, arranged from the level, not of the surface of the ground, but of excavations made in the mountain by the prehistoric builders. On the south, the wall ends at a short distance before reaching the precipice; and here are found traces of an opening or the gate to the inclosure, which is about eight feet wide at the bottom. In the interior of the fortification are a smaller wall, still intact, and piles of stones, the remains of former habitations, the greater part of which have, however, disappeared. Those which have been traced were of an oval form, about twenty feet long by six and a half feet wide, sometimes grouped, sometimes isolated, but arranged apparently so as to conform to some politic regulation. When the ruins were first discovered, the bones of many animals which are now extinct in Spain, as well as those of some still living in the country, were found at the bottom of the wall. Without the inclosure were found stone implements, polished hatchets of a white, reddish-veined quartz, lance-points of blackish diorite, and other objects of the polished-stone age. Such a work could only have been constructed by a settled population, who had already attained considerable numbers. No traditions of the historic period mention such fortifications; and on this fact, as well as on the occurrence of the remains of animals that have not lived in Spain for time immemorial, is based the presumption that the structure dates from

an extreme antiquity. This is one of the most important works of this kind that have attracted the attention of European archæologists.

NOTES.

Professor O. N. Rood, of Columbia College, describes, in a late number of the "American Journal of Science," a modification of the Sprengel pump, by which he has been able to obtain a vacuum of $\frac{1}{390000000}$ "without finding that the limit of its action had been reached."

Alden B. Hurt, not Huet, as it was wrongly printed, is the name of the author of the article "Union of the Telegraph and Postal Service" published in the July "Monthly."

The center of population of the United States appears now to have reached a point in latitude 39° 03′, about five miles west of Covington, Kentucky, ten miles east of the boundary-line between Indiana and Ohio, and fifty-one miles west and a few miles south of the point it reached in 1870. It has moved westward about four hundred and fifty miles since 1790.

Mr. John Fergus McLennan, an industrious student in anthropology, died in June of lung-disease, from which he had suffered for many years, aggravated by a fever caught in Algeria. His investigations were directed chiefly to the history of institutions. Their results were given principally in his essays on "Plant and Animal Worship," in the "Fortnightly Review," which first drew attention to the distribution and historical importance of totemism, and in his essays on "Primitive Marriage."

A French scientific journal relates an incident illustrating the susceptibility of spiders to music. A party at a country-house had formed a quartet and were performing a number of pieces, when two spiders were observed to descend upon their threads and hang near the top of the window of the room. They continued there for an hour, and did not go back to their nests till the music had stopped.

Dr. Beddoe and Mr. Tuckett have stated that "British heads are smaller than British heads used to be," and Mr. Horsfall, in the "Manchester Guardian," infers from this and other facts that the English people are physically deteriorating. The conditions under which youth are brought up in these days, without access to play-grounds and public gymnasia, with smoking and drinking as their principal recreations, are such as to favor the stunting of the race. The "Lancet"' takes up the thought, and points to the mode of life of a large number of urban people as the great evil of civilization. It urges the multiplication of places for open-air recreation and gymnasia, with increased freedom of admission to them.

The ninth award of the Rumford medal has been made by the American Academy of Arts and Sciences to Professor J. Willard Gibbs, for his researches on thermo-dynamics, and the medal was formally conferred upon that gentleman in January last. Professor Gibbs, in entering upon his investigation on the "Equilibrium of Heterogeneous Substances," the work for which the medal was conferred, took his departure from the two propositions enunciated by Clausius, that "the energy of the world is constant," and "the entropy of the world" (that is, the energy not available for work) "tends constantly toward a maximum," and held as his leading object to develop the parts of energy and entropy in the theory of thermodynamic equilibrium. His researches were declared by the President of the Academy to be "the consummate flower and fruit of seeds planted by Rumford himself, though in an unpromising soil, almost a century ago," when he showed how water could be boiled by the heat developed in boring a cannon.

Sir Josiah Mason, founder of the Mason Science College, died at Birmingham, England, in June, at the age of eighty-six years. He rose from the humblest ranks, having begun life as a street hawker and Jack-at-all-trades. He became employed in the gilt toy trade in 1814, and engaged in the manufacture of split rings in 1822. He afterward added the manufacture of steel pens, and became the greatest producer of them. He established an orphanage at Edlington in 1860, expending £300,000 upon it, and received the honor of knighthood in acknowledgment of his work. He afterward built up and endowed the Mason Science College, the inaugural address of which was delivered by Professor Huxley, giving it a total sum of about a quarter of a million pounds sterling.

M. de Bisschop has won a prize of one thousand francs, or two hundred dollars, for a small motor suited to use in families. His engine is worked by gas, and the operation costs, at the prices current in Paris, two cents an hour for machines doing a work of 36·17 foot-pounds per second, five cents an hour for machines performing at the rate of 180·8 foot-pounds per second. The smaller machines are sold for one hundred dollars; the larger ones for one hundred and eighty dollars.

The French Minister of Public Instruction is organizing at the Trocadéro a museum of ethnography, to contain the collections of the exploring parties by which France is represented, in nearly every quarter of the world, which will be under the charge of M. Armand Landrin and M. Hamy. The American department is nearly ready to be opened. It is arranged in geographical order, beginning with Alaska, Labrador, and Canada, and ending with Brazil. The departments of the states farther south must for the present remain empty for the want of specimens. California is represented by a tomb made of sand, shells, and kitchen-midden stuff, containing the bones of the deceased, by collections of cut flints, dolls, toys, and idols; Mexico by mummies—some of which are very well preserved, while others are but skin and bones—mirrors of polished pyrites, and all kinds of divinities.

Herr Holtz has concluded, from the comparison of the statistics of thunderstorms and the damage occasioned by them in Germany, Austria, and Switzerland, from 1854 to 1870, that, while the increase in thunderstorms has been small, the risk from lightning has been very largely augmented. He believes the change to be partly due to the destruction of forests, the extension of railways, and the use of iron in house-building.

Professor George Rolleston, Linacre Professor of Anatomy and Physiology in the University of Oxford, died in June, at his home in Oxford, in his fifty-second year. His life was one of scientific activity. He began his career, after being admitted to practice as a physician, as assistant surgeon in the British Civil Hospital at Smyrna during the Crimean War. He became Lee's Reader in Anatomy at Christ Church College, Oxford, in 1857, and was appointed to his professorship, as the first to occupy the newly founded chair, in 1860. He is best known by his work on "The Forms of Animal Life," an outline of zoölogical classification based upon anatomical investigations, by his important contributions to Canon Greenwell's "British Barrows," and by numerous contributions to the "Transactions" of the Royal Linnæan and Archæological Societies, and to many scientific journals.

Professor Ira Remsen has recently reported to the National Board of Health, the result of investigations he has made to ascertain whether carbonic oxide escapes from cast-iron stoves and furnaces in sufficient quantities to be dangerous. French chemists have asserted that it does; experiments made in Germany have failed to sustain their conclusion. Professor Remsen used Vogel's test for carbonic oxide, as improved by Hempel, and was able to detect as small a quantity as 0·04 parts of the oxide to 1,000 of air, while Vogel by his original test could not detect a smaller proportion than 2·5 parts per 1,000. In a careful examination of several furnaces in Baltimore, including some bad ones, carbonic oxide was not detected in a single case. A stove of peculiar construction was experimented upon under various conditions, to ascertain whether carbonic oxide actually passes through cast-iron heated to redness, with the result that none of the gas was found escaping. The conclusion is therefore drawn that if carbonic oxide is present in rooms it is in a smaller proportion than 0·04 parts per 1,000; and it remains to be shown whether so small a quantity is dangerous to health.

Among the recent entomological contributions to the "American Naturalist" is one by George Marx, of Washington, D. C., on a tube-constructing spider which he has discovered in the grounds of grass lands. The nests of these insects are outwardly about three quarters of an inch high, composed of grass, sticks of wood, etc., and much resembling a bird's nest. Within they are cylindrical, and communicate with a shaft some eight or nine inches deep, at the bottom of which was found (in October) a torpid spider. The nest and tube were strengthened by a lining resembling a very fine tissue-paper, which showed under the microscope no web-structure, but a hardened tissue, like varnish. Several of the nests were found, all constructed on the same plan. Nests of a similar character, but not identical, are described by Mr. Nicholas Pike, Mr. S. H. Scudder, and Mrs. M. Treat, as having been found in the sand near the seashore. Mr. Marx believes his specimens to be of a different species from the others, chiefly because the nests of the latter appeared to be used in summer and to contain eggs, while his nests were fresh in the fall, dilapidated and empty in the summer, indicating that they were used only as winter residences.

Professor J. W. Mallet has published an account of his determinations of the atomic weight of aluminum by series of experiments in three methods. The first method was by the ignition of ammonia alum, the second by the precipitation of the bromine in aluminum bromide by silver, and the third by the evolution of hydrogen through the action of metallic aluminum upon sodium hydrate. In the last method the hydrogen was determined, first, by the direct measurement of its volume, and, second, by weighing the water produced by its oxidation. The mean result of thirty experiments, ten in the first method, eleven in the second, and nine in the third, rejecting one of the results as too wide of the mark, was 27·02.

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PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

REMEDIAL EDUCATION (*continued*).

THE vicissitudes necessarily incident to an out-door and primitive mode of life are never the first causes of any disease, though they may sometimes betray its presence. *Bronchitis*, nowadays perhaps the most frequent of all infantile diseases, makes no exception to this rule; a draught of cold air may reveal the latent progress of the disorder, but its cause is long confinement in a vitiated and overheated atmosphere, and its proper remedy ventilation and a mild, phlegm-loosening (saccharine) diet, warm sweet milk, sweet oatmeal-porridge, or honey-water. Select an airy bedroom and do not be afraid to open the windows; among the children of the Indian tribes who brave in open tents the terrible winters of the Hudson Bay territory, bronchitis, croup, and diphtheria are wholly unknown; and what we call "taking cold" might often be more correctly described as taking *hot;* glowing stoves, and even open fires, in a night-nursery, greatly aggravate the pernicious effects of an impure atmosphere. The first paroxysm of *croup* can be promptly relieved by very simple remedies: fresh air and a rapid forward-and-backward movement of the arms, combined in urgent cases with the application of a flesh-brush (or piece of flannel) to the neck and the upper part of the chest. Paregoric and poppy-sirup stop the cough by lethargizing the irritability and thus preventing the discharge of the phlegm till its accumulation produces a second and far more dangerous paroxysm. These second attacks of croup (after the administration of palliatives) are generally the fatal ones. When the child is convalescing, let him beware of stimulating food and overheated rooms. Do not give aperient medi-

cines; costiveness, as an after-effect of pleuritic affections, will soon yield to fresh air and a vegetable diet.

Worms.—Intestinal parasites are symptoms rather than a cause of defective digestion, and drastic medicines (calomel, Glauber's-salt, etc.) are merely palliatives; even a change of diet may fail to afford permanent relief if the general mode of life favors a costive condition of the bowels. Like maggots, maw-worms seem to thrive only on putrescent substances, on accumulated ingesta in a state of self-decomposition, and disappear as soon as exercise, cold fresh air, and a frugal diet have reëstablished the functional vigor of the digestive organs.

Diarrhœa.—An abnormal looseness of the bowels is an effort of Nature to rid the stomach of some irritating substance, and suggests the agency of a dietetic abuse, either in quantity or in quality. An excessive quantum even of the healthiest food will purge the bowels like a drastic poison, unless the alimentary wants—and consequently the assimilative abilities of the system—have been increased by active exercise. On the hunting-grounds of the upper Alps, an Austrian sportsman can assimilate a quantity of meat which the kitchen artists of the best Vienna restaurant could not have foisted upon the stomach of an indolent burgher. Dysentery medicines can be entirely dispensed with if one can get the patient to try the effect of Nature's two specifics—fasting and pedestrian exercise. Combined they will only fail when opiates have produced an inflammatory condition of the bowels, in which case a grape- or water-cure must precede the more radical remedies. The languor of dysentery is always combined with a fretful restlessness, and should not be mistaken for the exhaustion that calls for repose and food: the patient is safe if we can fatigue him into actual sleepiness, or anything like a genuine appetite; when the digestive organs announce the need of nourishment, they can be relied upon to find ways and means to retain it.

Constipation.—A slight stringency of the bowels should never be interfered with; in summer-time close stools are consistent with a good appetite and general bodily vigor. Aperient medicines provoke a morbid activity of the bowels, followed by a costiveness that differs from a summer constipation as insomnia differs from a transient sleeplessness. In England and the United States the use of laxative drugs has repeatedly become epidemic and in its consequences a true national misfortune;* and a sad majority of otherwise intelligent parents are still afflicted with the idea that children have to "take something"—in other words, that their bowels have to be convulsed with

* "If the bowels become constipated, they are dosed with pills, with black draughts, with brimstone and treacle, and medicines of that class, almost *ad infinitum*. Opening medicines, by constant repetition, lose their effects, and therefore require to be made stronger and stronger, until at length the strongest will scarcely act at all; . . . the patients become dull and listless, requiring daily doses of physic until they almost live on medicine."—(H. Chavasse, "Advice to a Mother," p. 388.)

poisons, for every trifling complaint. Constipation is often simply a transient lassitude of the system, a functional tardiness caused by fatigue and perspiration, and very apt to cure itself in the course of two or three days, especially at a change from a higher to a lower temperature. After the third day the disorder demands a change of regimen: cold ablutions, lighter bedclothes, in summer-time removal of the bed to the coolest and airiest available locality, and liberal rations of the most digestible food—bran-bread, sweet cold milk, stewed prunes, and fresh fruit in any desired quantity; *faute de mieux*, cold water and sugar, oatmeal-gruel, and diluted molasses. The legumina, in all their combinations, are likewise very efficient bowel regulators, and common pea-soup is a remedial equivalent of Du Barry's expensive "revalenta Arabica" (lentil-powder). For real dyspepsia (rarely a chronic disease of youngsters in their teens), there is hardly any help but rough out-door exercise, daily pedestrian exercise or out-door labor, continued for hours in all kinds of weather. The Graham starvation cure might bring relief in the course of time, but for one person with passive heroism enough to resist the continual cravings of an abnormal appetite, hundreds can muster the requisite resolution for an occasional active effort, which will gradually but perceptibly restore the vigor of the system. Drugs only change the form of the disease by turning a confirmed surfeit-habit into a still more obstinate and less commutable alcohol-habit; the vile mixtures sold under the name of "tonic" bitters have never benefited anybody but their proprietors and the rum-sellers, to whose army of victims the patent-medicine dispensaries serve as so many recruiting-offices.

Active exercise is also the only remedy for those *secret vices* whose causes are as often misunderstood as their consequences. The pathologists who ascribe precocious prurience to the effects of a stimulating diet seem to overlook the fact that the most continent nations of antiquity, the Scythians and ancient Germans, were as nearly exclusively carnivorous as our Indian hunting-tribes, the apathy of whose sexual instincts has been alleged in explanation of their gradual extinction.* For the same reason the gauchos of the tropical pampas are an unprolific race, while the Russian mujiks and the sluggish boyars of the Danubian principalities are as salacious as the inert (though frugivorous) natives of southern Italy. Independent of climate and diet, the continence or incontinence of the different nations, or different classes of any nation, bears an unmistakable proportion to the degree of their indolence. Lazy cities and small, thickly populated islands (Lesbos, Paphos, Cythera, Otaheite) have been most conspicuous for the absence of those virtues which the Grecian allegory ascribed to the goddess of the chase. The *menu* prescribed by the founders of the monastic orders was rather ultra-Grahamite in quality and quantity, yet neither barley-bread nor the frequent fasts to aid the

* Ludwig, "American Aborigines," p. 128.

minutio monachi could counteract the effects of deficient exercise; if we can believe the publicists of the Reformation, the *chronique scandaleuse* of Lesbos and Capri was far surpassed in the record of some mediæval convents—and not in the flagrant latitude of Italy alone (Robert Burton's "Anatomy of Melancholy," volume of miscellanies, pp. 449–451, quotations, etc.). Nor can we mistake the significance of the circumstance that sexual aberrations in the years of immaturity are almost exclusively the vice of male children, whose potential energies, with the same diet and the same general mode of life, find no adequate vent in an amount of active exercise nearly sufficient for the constitutional wants of the other sex. Moral lectures are sadly ineffectual in such cases, because, as Gotthold Lessing remarks, vicious passions pervert the constitution of the mind as effectually as they subvert that of the body—"the evil powers blindfold the victims of their altars." A frugal diet may subserve the work of reform, but the great specific is competitive gymnastics, the society and example of merry, manly, and adventurous companions. Crank-work gymnastics won't do; enlist the pride of the young Trimalchion, watch him at play, find out his special *forte*, no matter what—running, jumping, or throwing stones—and organize a sodality for the cultivation of that particular accomplishment. Beguile him into heroic efforts, offer prizes and champion-badges: as soon as manful exercises become a pleasure, unmanning indulgences will lose their attractions. The depressing after-effect of sensual excesses, the dreary reaction, is a chief incentive to the repetition of the vicious act, and the success of all reformatory measures depends at first upon the possibility of relieving this depression by healthful diversion, till, in the course of time, regained mental and bodily vigor will help the remedial tendency of Nature to neutralize the morbid inclination.

"*Rickets*" is a sign of general debility, owing to mal-nutrition during the years of rapid growth. The best physic for a rickety child is milk, bran-bread, and fruit; the best physician, the drill-master of the turner-hall. Rickety children are apt to be precocious, and till their backs are straightened up their books ought to be thrown aside. Knock-knees, bow-legs, "chicken-breasts," and round shoulders are all amenable to treatment, if the cure be begun in time—during the first three years of the teens, of all ages at once the most plastic and the most retentive of deep impressions.

For the cure of young *topers*, *smokers*, and *gluttons* I am persuaded that punishments are only of temporary avail, and homilies of no use whatever. The most glowing eloquence palls before the suasion of a vicious *penchant*. Here, too, the chances of saving the tempted depend upon the possibility of silencing the tempter—by outbidding his offer. Provide healthful diversions; the victims of the poison-habit yield to temptation when the reaction (following upon every morbid excitement) becomes intolerable. Relieve the strain of that

reaction by diverting sports; improvise hunting expeditions and mountain-excursions, or Olympic games; between exciting diversions and sound sleep the toper will forget his tipple, and every day thus gained will lessen the danger of a relapse.

It can not be denied that *poison-habits* (the opium-habit as well as "alcoholism") are to some degree hereditary. The children of confirmed inebriates should be carefully guarded, not only against objective temptations, but against the promptings of a peculiar disposition which I have found to be a (periodical) characteristic of their mental constitution. They lack that spontaneous gayety which constitutes the almost misfortune-proof happiness of normal children, and, without being positively peevish or melancholy, their spirits seem to be clouded by an apathy which yields only to strong external excitants. But healthful amusements and healthy food rarely fail to restore the tone of the mind, and, even before the age of puberty, the manifestations of a more buoyant temper will prove that the patient has outgrown the hereditary hebetude, and with it the need of artificial stimulation.

Chlorosis, or green-sickness, is a malignant form of that dyspeptic pallor and languor which one half of our city girls owe to their sedentary occupations in ill-ventilated rooms. The complaint is almost unknown in rural districts, and the best cure is a mountain-excursion, afoot or on horseback; the next best a course of "calisthenics," a plentiful and varying vegetable diet, fun, frequent baths, and plenty of sleep. "Tonic" drugs are sure to aggravate the evil. It is only too well known that a fit of nervous depression can be *momentarily* relieved by a cup of strong green tea. The stimulus goads the weary system into a spasm of morbid activity: the vital strength, sorely needed for a reconstructive process (one of whose phases was the nervous depression), has now to be used to repel a pernicious intruder; and this convulsion of the organism, in its effort to rid itself of the narcotic poison, is mistaken for a sign of returning vigor—the patient "feels so much better." But, as soon as the irritant has been eliminated, the vital energy—diminished now by the expulsive effort—has to resume the work of reconstruction under less favorable circumstances; the patient now "feels so much worse"—by just as much as the reaction following upon the morbid excitement has since increased the nervous depression. In the same way precisely a "tonic" medicine operates upon the exhausted organism, and in the same way its effect—a morbid and transient stimulation—is mistaken for a permanent invigoration.

Pulmonary consumption, in its early stages, is perhaps the most curable of all chronic diseases. The records of the dissecting-room prove that in numerous cases lungs, wasted to one half of their normal size, have been healed, and, after a perfect cicatrization of the tuberculous ulcers, have for years performed all the essential functions of

the sound organ. Still, the actual waste of tissue is never perfectly repaired, and fragmentary lungs, supplying the undiminished wants of the whole organism, must necessarily do double work, and will be less able to respond to the demands of an abnormal exigency. But the lungs of a young child of consumptive parents are sound, though very sensitive, and, if the climacteric of the first teens has been passed in safety, or without too serious damage, the problem becomes reduced to the work of preservation and invigoration: the all but intact lungs of the healthy child can be more perfectly redeemed than the rudimentary organs of the far-gone consumptive; the phthisical taint can be more entirely eliminated and the respiratory apparatus strengthened to the degree of becoming the most vigorous part of the organism. The poet Goethe, afflicted in his childhood with spitting of blood and other hectic symptoms, thus completely redeemed himself by a judicious system of self-culture. Chateaubriand, a child of consumptive parents, steeled his constitution by traveling and fasting, and reached his eightieth year. By a relapse into imprudent habits, the latent spark, which under such circumstances seems to defy the eliminative efforts of half a century, may at any time be fanned into life-consuming flames, but in ninety-nine out of a hundred cases it will be found that the first improvement followed upon a change from a sedentary to an out-door and active mode of life. Impure air is the original cause of pulmonary consumption ("pulmonary scrofula," as Dr. Haller used to call it), and out-door life the only radical cure. The first symptoms of consumption are not easy to distinguish from those transient affections of the upper air-passages which are undoubtedly due to long confinement in a vitiated atmosphere: hoarseness, and a dry, rasping cough, rapid pulse, and general lassitude. Spitting of blood and pains in the chest are more characteristic symptoms, but the crucial test is the degree in which the respiratory functions are accelerated by any unusual effort. A common catarrh will not prevent a man from running up-stairs or walking up-hill for minutes together, without anything like visible distress; subjected to the same test, a person whose lungs are studded with tubercles will pant like a swimmer after a long dive, and his pulse will rise from an average of 65 to 110 and even 140 beats per minute. Combined with a hectic flush of the face, night-sweats, or general emaciation, shortness of breath leaves no doubt that the person thus affected is in the first stage of pulmonary consumption. If the patient were my son, I should remove the windows of his bedroom, and make him pass his days in the open air—as a cow-boy or berry-gatherer, if he could do no better. In case the disease had reached its *deliquium* period, the stage of violent bowel-complaints, dropsical swellings, and utter prostration, it would be better to let the sufferer die in peace, but, as long as he were able to digest a frugal meal and walk two miles on level ground, I should begin the out-door cure at any time of the year, and stake my own life on the result. I

should provide him with clothing enough to defy the vicissitudes of the seasons, and keep him out-doors in all kinds of weather—walking, riding, or sitting ; he would be safe : the fresh air would prevent the *progress* of the disease. But *improve* he could not without exercise. Increased exercise is the price of increased vigor. Running and walking steel the leg-sinews. In order to strengthen his wrist-joints a man must handle heavy weights. Almost any bodily exercise—but especially swinging, wood-chopping, carrying weights, and walking uphill—increases the action of the lungs, and thus gradually their functional vigor. Gymnastics that expand the chest facilitate the action of the respiratory organs, and have the collateral advantage of strengthening the sinews, and invigorating the system in general, by accelerating every function of the vital process. The exponents of the movement-cure give a long list of athletic evolutions, warranted to widen out the chest as infallibly as French-horn practice expands the cheeks. But the trouble with such machine-exercises is that they are almost sure to be discontinued as soon as they have relieved a momentary distress, and, as Dr. Pitcher remarks in his "Memoirs of the Osage Indians," the symptoms of consumption (caused by smoking and confinement in winter quarters) disappear during their annual buffalo-hunt, but reappear upon their return to the indolent life of the wigwam. The problem is to make out-door exercise pleasant enough to be permanently preferable to the *far niente* whose sweets seem especially tempting to consumptives. This purpose accomplished, the steady progress of convalescence is generally insured, for the differences of climate, latitude, and altitude, of age and previous habits, almost disappear before the advantages of an habitual out-door life over the healthiest in-door occupations.

A tubercular diathesis inherited from both parents need not be considered an insuperable obstacle to a successful issue of the cure. The family of my old colleague, Dr. G——, of Namur, adopted a young relative who had lost his parents and his only brother by febrile consumption, and was supposed to be in an advanced stage of the same disease. The Antwerp doctors had given him up, his complaint having reached the stage of night-sweats and hectic chills, and, though by no means resigned to the verdict of the medical tribunal, he had an unfortunate aversion to anything like rough physical exercise. But his uncle, having from personal experience a supreme faith in the efficacy of the open-air cure, set about to study the character of the youngster, and finally hit upon a plan which resulted in the proudest triumph of his professional career. Pierre was neither a sportsman nor much of an amateur naturalist, but he had a fair share of what our phrenologists call "constructiveness"—could whittle out ingenious toys and make useful garden-chairs from cudgels and scraps of old iron. That proved a sufficient base of operations. The doctor had no farm of his own, and the only real estate in the market was a lot of

poor old pastures on a sparsely wooded slope of the Ardennes. Of this pasture-land he bought some ten or twelve acres, including a hill-top with a few shade-trees and a fine view toward the valley of the Sambre. At the first opportunity one of Pierre's garden-chairs was sent up to the lookout point, but rain and rough usage soon reduced it to its component elements—scrap-iron and loose cudgels. Pierre volunteered to repair it, and was supplied with such a variety of material and tools that he made two more chairs, and while he was about it also a rustic round-table with a center-hole, corresponding to the diameter of one of the shade-trees. The hill was only two miles from town, and soon became a favorite evening resort of the G—— family; but the road was rather steep, and Mrs. G—— appealed to the ingenuity of her constructive nephew: could he not try and make a winding trail by knocking some of the rocks and bushes out of the way? Pierre tried, and his success, the uncle declared, proved him and intuitive engineer, the peer of Haussmann and Brunel. That new road had so increased the value of the old pasture that it would be worth while to put up a pavilion and make it a regular hill-top resort. The only drawback upon the advantage of its situation was the want of good drinking-water; but there was a sort of a spring in an adjoining pasture on the opposite slope of the ridge: would Pierre make an estimate of the number of bricks requisite to wall it up and keep the cattle from muddling it? The requisition proved an under-estimate, but Pierre made up the deficiency by collecting a lot of passably square stones. The water now became drinkable, and somehow the rumor got abroad that Pierre had *discovered* the spring, whereupon his uncle's neighbor urged him to exercise his talent for the benefit of his valley-meadow, in all but the want of water the best pasture in the parish. Pierre selected a spot where a lot of day-laborers were set to work and actually struck water—by digging deep enough. The gratitude of the farmer was almost too demonstrative for the modest lad, who, however, agreed with his uncle that a talent of that sort might make its possessor a public benefactor, and ought to be cultivated. Would Pierre undertake to locate a well on his uncle's hill-pasture, a little nearer to the lookout point? The brick-spring was too far down, and it would be so convenient to have water on one's own premises! Judging from analogies, the young hydrologist fixed upon a spot at the junction of two ravines, but too near the upper boundary of arboreal vegetation, and after digging down to a stratum of dry sandstone detritus, the workmen gave up the job in disgust. But Pierre himself would not yield his point, and offered to dig the well alone if they would give him time, and a boy to turn the windlass of the sand-bucket. His wish was granted, and before he had been a week at work, his asthma had left him, his digestion improved, and his appetite became ravenous. The well-project had finally to be relinquished, but his uncle consoled him by purchasing the adjoining lot and letting him

make a winding road from the brick-spring to the hill-top. The road was built, but Pierre indorsed the opinion of a professional engineer that the well-hole, too, would be full of water if the woods of the upper ridge had not been so ruthlessly destroyed and that the replanting of forest-trees along the line of the subterranean water-courses would not only replenish the springs but redeem the arid pastures of the foot-hills. The doctor controverted that point, but—just for the sake of experiment—procured a hundred beech-tree saplings, which Pierre planted and watered with untiring assiduity. Some sixty per cent. of the trees took root, to the unending astonishment of the uncle, who now declared that his confidence in the fertility of the ridge-land had increased to a degree which encouraged him to try his luck with orchard-trees. They procured a lot of young apple, almond, and apricot trees, about two hundred of each, and planted them along the line of the suppositive water-courses. Pierre superintended the work, and was kept so busy for the next eighteen months that he had no time to be sick for a single day. The boy that was given up by the Antwerp doctors is now a well-to-do horticulturist, able to climb without a stop the steepest ridge in the Ardennes and to fell a forty-years oak-tree in twenty minutes!

In the beginning of this chapter I have mentioned two forms of disease which, thus far, have not proved amenable to the hygienic (non-medicinal) mode of treatment, though it has already been ascertained that a mild vegetable demulcent—sarsaparilla, for instance—is as efficacious in those cases as the virulent mercurials of the old school. Antidotes and certain anodynes will, perhaps, also hold their own till we find a way of producing their effects by *mechanical* means. But, with these few exceptions, I will venture the prediction that, before the middle of the twentieth century, the internal use of drugs will be discarded by all intelligent physicians.

"If we reflect upon the obstinate health of animals and savages," says Dr. Schrodt, "upon the rapidity of their recovery from injuries that defy all the mixtures of materia medica; also upon the fact that the homœopathists cure their patients with milk-sugar and mummery, the prayer-Christians with mummery without milk-sugar, and my followers with a milk-diet without sugar or mummery—the conclusion forces itself upon us that the entire system of therapeutics is founded upon an erroneous view of disease."

And, moreover, I believe that the chief error can be accounted for: it is founded upon our erroneous view of the cause and cure of evil in general. Translated into plain speech, the foundation-principle of our system of ethics is this: that all natural things, especially our natural instincts, are essentially evil, and that salvation depends upon mysterious, anti-natural, and even supernatural remedies. This bottom-error has long biased all our physical and metaphysical theories. The use of our reasoning powers is naturally as agreeable as the exercise of

any other normal function: the anti-naturalists declared war against free inquiry, assured us that the study of logic and natural science is highly dangerous, and that the seeker after truth must content himself with the light of ghostly revelations. We have since ascertained that the ghosts are grossly ignorant of all terrestrial concernments, and that their reports on the supramundane state of affairs are, to say the least, suspiciously conflicting.

In all but the vilest creatures the love of freedom is as powerful as the instinct of self-preservation: the anti-naturalists inculcated the dogma of implicit submission to secular and spiritual authorities. The experiment was tried on the grandest scale, and the result has demonstrated that blind faith leads to idiocy, and that absolute monarchs must be absolutely abolished.

The testimony of our noses justifies the opinion that fresh air is preferable to prison-smells; the anti-naturalists informed us that at various seasons of the year, and every night, the out-door atmosphere becomes mortiferous, and that sleepers and invalids ought to be confined in air-tight apartments. We believed, till we found that the most implicit believers got rotten with scrofula.

Animals seem to live and thrive on the principle that palatable food recommends itself to the stomach, and that repulsive things ought to be avoided. The anti-naturalists reversed the maxim, and assured us that sweetmeats, uncooked vegetables, cold water, drunk when it tastes best—i. e., on a warm day—raw fruit, etc., are the causes of countless diseases, and that the execrable taste of a drug is not the least argument against its salubriousness. During the middle ages parents used to dose their children with brimstone and calomel, "to purify their blood," and, for the same purpose, the most nauseous mineral springs of every country are still pumped and bottled for the benefit of invalids. There is not a poison known to chemistry or botany but has been, and is still, daily prescribed as a health-giving substance, and, in the form of pills, drops, or powders, foisted upon a host of help-seeking invalids. But, since the revival of free inquiry, we have compared the statements of ancient historians and modern travelers, and it appears that the healthiest nations on earth have preserved their health on the principle that guides our dumb fellow-creatures, and would guide our children if they were permitted to follow their inclinations. An overwhelming testimony of facts has proved that the diseases of the human race can be cured easier without poison-drugs—easier in the very degree that would suggest the suspicion that every ounce of poison ever swallowed for remedial purposes has increased the weight of human misery.* And that same suspicion is forced upon us by

* "It is unnecessary for my present purpose to give a particular account of the results of homœopathy; . . . what I now claim with respect to it is, that a wise and beneficent Providence is using it to expose and break up a deep delusion. In the results of homœopathic practice, we have evidence in amount, and of a character sufficient, most incontestably

very cogent *a priori* reasons. If the testimony of our senses helps us to select our proper food, and warns us against injurious substances, have we any reason to suppose that such salutary intuitions forsake us at the time of the greatest need—in the hour of our struggle with a life-endangering disease? Shall we believe that at such times our sense of taste *warns us* against salubrious substances? And does it not urgently warn us against ninety-nine out of a hundred "medicines"? Shall the sick believe that an all-wise Creator has staked the chances of their recovery upon the accident of their acquaintance with Dr. Quack's Quinine Bitters or Puff & Co.'s Purgative Pills? Yet, is it possible to mistake the analogy between the remedial theories of our nostrum-mongers and the alleged moral "plan of salvation"? Is not the key-note of the Semitic dogma mistrust of our natural instincts and reliance upon abnormal remedies—mummeries, mysteries, and miracles?

Poison-mongers, physical or spiritual, will cease to be in request whenever their customers begin to suspect that this world of ours is governed by laws, and not by special acts of intervention; that sickness can be cured only by conformity to those laws, and not by drugs and prayers—i. e., anti natural and supernatural remedies. To the children of Nature all good things are attractive, all evil repulsive: the laws of God proclaim and avenge themselves; the Author of this logically-ordered universe can never have intended that our salvation should depend upon the accident of our acquaintance with the dogmas of an isolated act of revelation; and, as surely as the germ of the hidden seed-corn finds its way through night to light, the unaided instincts of the lowliest islander would guide him safely on the path of moral and physical welfare.

These words would be truisms if Truth had not been a contraband for the last eighteen hundred years: To nine tenths of our Christian contemporaries God's most authentic revelation is still a sealed book; and, before any reformer can hope to turn this chaos of vice, superstition, and quackery, into anything like a cosmos, he *must* convince his fellow-men that the study of Nature has to supersede the worship of miracles, even though that conviction should imply that the fundamental dogmas of our priest-religion are perniciously false.

to establish the fact that disease is a restorative operation, or renovating process, and that medicine has deceived us. The evidence is full and complete. It does not consist merely of a few isolated cases, whose recovery might be attributed to fortuitous circumstances, but it is a chain of testimony fortified by every possible circumstance. . . . All kinds and grades of disease have passed under the ordeal, and all classes and characters of persons have been concerned in the experiment as patients or witnesses; . . . *while the process of infinitesimally attenuating the drugs used was carried to such a ridiculous extent that no one will, on sober reflection, attribute any portion of the cure to the medicine.* I claim, then, that homœopathy may be regarded as a providential sealing of the fate of old medical views and practice."—(Isaac Jennings, M. D., "Medical Reform," p. 247.)

THE PRACTICAL BUSINESS OF LIFE INSURANCE.

By THEODORE WEHLE.

THE mortality tables, forming the theoretical basis of life insurance, having been explained, it remains to be shown how they are employed in practice. There is a fundamental difference between life and fire or marine insurance that must first be considered. The hazard attaching to a building or a ship may remain unchanged for a very long term of years, and the rate of premium once determined need not be altered. Such property is usually insured for one year at a time, and renewed as often as desirable. But the same methods can not be applied to human life. If the policy were to terminate annually, and a new examination could be demanded, many persons whose health had become impaired would be declined at the beginning of every new year. Then, as has been shown, from a very young age, upward, the rate of mortality constantly increases. That would necessitate a higher premium charge from year to year, so that, finally, a person who should be fortunate enough to reach the highest age of the table would have to pay one hundred per cent. for that one year. It requires no argument to prove such a system impracticable, and therefore the plan of fixing one uniform periodic premium for the whole term of the proposed insurance has been adopted.

The following table shows, in one column, the amount of *net* premium that must be paid at the beginning of every year to insure $1,000 for that year; and, in the other column, the equal *net* annual premium to insure for life.

By net premium is meant the amount calculated from a certain mortality table, and rate of interest, without any addition for expenses.

In all illustrations hereafter given the American Experience Table and four and a half per cent. interest will be employed, that being the official standard for the State of New York.

Age.	Net premium for one year.	Net annual premium for life.	Age.	Net premium for one year.	Net annual premium for life.
20	$7 47	$11 97	60	$25 54	$54 14
21	7 51	12 23	70	59 61	97 00
22	7 57	12 50	80	138 24	188 20
			90	434 96	494 33
30	8 06	15 34	94	820 22	836 69
40	9 37	21 30	95	956 93	956 93
50	13 19	32 49			

From this table it appears that, to insure $1,000 for one year at a time, it would cost $7.47 at age 20, and that the amount would have to be continually increased, until at age 90 it would be $434.96, while

the same purpose would be accomplished for an equal annual premium of \$11.97. The somewhat larger expense in the earlier years of insurance avoids the necessity of enormous charges at the high ages.

The method of arriving at the equal annual premium is based upon very plain reasoning, and can be explained in a simple manner.

Let us assume, with the American Experience Table, that, out of 100,000 persons at age 10, there remain 847 living at age 90, and that they die, according to the table, as follows :

Age.	Number living.	Number of deaths.
90	847	385
91	462	246
92	216	137
93	79	58
94	21	18
95	3	3
	1,628	847

Were these 847 to form an association, based on the condition that the payments remain equal throughout, and be collected from the survivors at the beginning of each year, and that \$1 be paid at the death of each member, there would be 1,628 contributions during the whole period, to provide for 847 death-claims. The requisite annual premium would therefore be $\frac{847}{1628}$ of a dollar, or \$0.52027 (52 + cents). Let us examine the working of this fund :

Age 90—living, 847 × ·52027 =	contributions...............	\$440 67	
	Death-claims...............	385 00	
	Balance....................		\$55 67
Age 91—living, 462 × ·52027 =	contributions...............	\$240 37	
	Balance....................	55 67	
		\$296 04	
	Death-claims...............	246 00	
	Balance....................		\$50 04
Age 92—living, 216 × ·52027 =	contributions...............	\$112 38	
	Balance....................	50 04	
		\$162 42	
	Death-claims...............	137 00	
	Balance....................		\$25 42
Age 93—living, 79 × ·52027 =	contributions...............	\$41 10	
	Balance....................	25 42	
		\$66 52	
	Death-claims...............	58 00	
	Balance....................		\$8 52

Age 94—living, 21 × ·52027 = contributions		$10 92	
	Balance	8 52	
		$19 44	
	Death-claims	18 00	
	Balance		$1 44
Age 95—living, 3 × ·52027 = contributions		$1 56	
	Balance	1 44	
		$3 00	
	Death-claims	3 00	

One important element, however, the investment of money at interest, has been omitted in the above illustration, and will be introduced now. It has already been stated that premiums are payable at the beginning, while death-claims are due at the end, of the same year. To bring these different amounts and dates to a common basis we must determine the present value of each, at the age at which the insurance begins. Knowing, from the table, the amounts of the contributions and the number of deaths and the time at which they become due, it is to be ascertained what amount of money deposited at the beginning of the period, improved at compound interest, would be equivalent to the total of these sums.

The present value of $1 at the beginning of the year, at 4½ per cent. interest, is $0·9569 ; that is to say, $0·9569 invested at 4½ per cent. interest will amount to $1 at the end of the year. The present value of $1 for two years is $0·9157, for three years $0·8763 ; or these amounts, improved at 4½ per cent. compound interest, will become $1 by the end of these years.

Applying this principle to the class of 847 persons under consideration, and assuming each contribution and each death-claim to be $1, we need only multiply these by the present value corresponding to each year, bearing in mind that the living pay in advance, while the death-claims are due at the end of the year :

Age.	Living.		Deaths.	
90	847 × $1 =	$847 00	385 × ·9569 =	$368 41
91	462 × ·9569 =	442 10	246 × ·9157 =	225 26
92	216 × ·9157 =	197 79	137 × ·8763 =	120 05
93	79 × ·8763 =	69 23	58 × ·8386 =	48 64
94	21 × ·8386 =	17 61	18 × ·8025 =	14 44
95	3 × ·8025 =	2 41	3 × ·7679 =	2 30
		$1,576 14		$779 10

The above calculation shows the present value of the 1,628 contributions, at $1 each, to be $1,576.14, and the present value of the 847 death-claims to be $779.10 ; therefore, to meet these latter, the contributions need only be, instead of one dollar, $\frac{77910}{157614}$ of one dollar, or $0·49432 (49 + cents). The item of interest has reduced the premium to $0·49432, when, without it, it would have been $0·52027.

Similarly to the annual premium, any other mode of payment may be determined; say, for instance, one single premium for life. At age 90 the present value of all future death-claims is $779.10, and there are 847 persons to provide for the same; therefore, each one must contribute $\frac{779\cdot10}{847}$, or $0·91987 in advance, that being the one single premium for life.

The limits of a magazine article do not permit more extended illustrations, but the reader can readily reason out for himself how premiums, insuring for life in a limited number of payments, and various other adaptations in vogue, all based upon the same principles, may be arrived at.

Let us now apply the annual premium of $0·49432, as above ascertained, to the insurance fund, and follow its working to the end, computing interest at $4\frac{1}{2}$ per cent.:

Age 90—Living...............	847 × ·49432 = $418 69 × 1·045 =	$437 53
	Death-claims at the end of the year,	385 00
	Balance,	$52 53
Age 91 "	462 × ·49432 = $228 37	
	Balance on hand, 52 53	
	$280.90 × 1·045 =	$293 55
	Death-claims at the end of the year,	246 00
	Balance,	$47 55
Age 92 "	216 × ·49432 = $106 77	
	Balance on hand, 47 55	
	$154 32 × 1·045 =	$161 27
	Death-claims at the end of the year,	137 00
	Balance,	$24 27
Age 93 "	79 × ·49432 = $39 05	
	Balance on hand, 24 27	
	$63 32 × 1·045 =	$66 18
	Death-claims at the end of the year,	58 00
	Balance,	$8 18
Age 94 "	21 × ·49432 = $10 38	
	Balance on hand, 8 18	
	$18 56 × 1·045 =	$19 39
	Death-claims at the end of the year,	18 00
	Balance,	$1 39
Age 95 "	3 × ·49432 = $1 48	
	Balance on hand, 1 39	
	$2 87 × 1·045 =	$3 00
	Death-claims at the end of the year,	3 00

It will be observed that, at the end of every year, with the exception of the last one, an unexpended balance remains; dividing this by the number of survivors, we get the amount that applies to each individual living at that period. This is called the net valuation, or, more commonly, the reserve for each policy.

At the ages we have under consideration, the reserve would be as follows:

End of Year.	Living.	Balance.	Reserve for each.
90	462	$52 53	$0·11370
91	216	47 55	0·22014
92	79	24 27	0·30721
93	21	8 18	0·38952
94	3	1 39	0.46261
95	..	....	......

While the reserve, as here given, is strictly correct in amount as well as in principle, other methods of calculation are employed in practice; but, for a simple explanation, the plan here adopted will probably serve better than any other. The difficulty has also been that the very high age of ninety had to be selected for the above illustrations, because every computation has to be carried to the end of the table, which would be very lengthy and tedious for a young age. But, the explanation having been given, a closer inspection of the reserves applying to age twenty will afford a broader insight into the subject:

Age 20—Net Annual Premium $11.97 per $1,000.

End of Year.	Death-rate, per cent.	Cost of insurance.	Reserve.
20	·780	$7 77	$4 74
21	·785	7 78	9 67
22	·790	7 79	14 82
30	·843	7 88	64 92
40	·979	8 27	155 80
44	1·083	8 63	203 05
45	1·116	8 75	215 94
50	1·378	9 83	286 56
60	2·669	14 65	451 27
70	6·199	23 33	623 60
94	85·714	47 17	944 97
95	100·000	00 00	1,000 00

From the above table it will be seen that the annual premium may be looked upon as consisting of two parts, one defraying the annual cost of insurance dependent upon the death-rate, the other put aside as a reserve fund. Up to a certain period the premium is larger than

the actual cost of insurance, but a time arrives when it does not suffice, and then a part of the interest on the reserve must contribute the difference. It will be noticed that the reserve grows constantly, so that by the end of the year 94 it is $944.97, and, with the annual premium of $11.97, due at the beginning of year 95, amounts to $956.94, which, invested at 4½ per cent. interest, will by the end of the year produce the sum of $1,000. Theoretically, then, there is no loss from a person dying according to the last year of the mortality table, because the whole amount of the sum insured has already accumulated under the reserve.

This reserve, too, may in a certain sense be said to have a twofold function: it not only provides for the future, but also annually reduces the amount at risk, whereby the cost of insurance becomes less than it would otherwise be. Thus, by the above table for the year 45, the cost of insurance is only $8.75, while the death-rate would amount to $11.16 per $1,000. The fact that the reserve has reached $215.94, and the amount at risk is only $784.06, reduces the cost from $11.16 to $8.75. For the year 94 the death-rate would amount to $857.14 per $1,000, while the cost of insurance is only $47.17, since the reserve has accumulated to $944.97, leaving but $55.03 at risk.

As a final illustration of the whole method take the reserve at the end of year 44, $203.05, add the annual premium of $11.97, being together $215.02, invest at 4½ per cent. interest, and it will amount to $224.69; deduct the cost of insurance, $8.75 (being the amount at risk $784.06 × 1·116 per cent., the death-rate), and the balance remaining, $215.94, is the reserve at the end of year 45.

But, however instructive these details, it may be well, to avoid confusion, to sum up the whole process in the statement that the annual premium is a device to collect a larger amount than the death-rate in the earlier years of insurance, and to use these over-payments, improved at compound interest, to meet the deficiencies which arise in later years. The premium and reserve are so nicely adjusted that they are strictly equitable for the living as well as the dying at every year of life.

The view of the reserve or net valuation here presented is distinctively American. It has been embodied in State legislation, and has an important bearing upon the question of surrender values, presently to be considered. There are other methods for determing the valuation, which take into account all future payments due, and all losses and expenses to be incurred to the end of the table; but these are questions beyond the scope of this article.

To the net premium of which we have treated, a certain percentage is added to defray expenses and to provide for contingencies; it is called *loading*, and together with the net premium constitutes what is known as gross or office premium. In mutual companies, the only ones that will be here considered, the loading is made higher than any

probable exigency will demand, so as to be absolutely safe. At fixed periods the amount collected, in excess of actual cost, is distributed among the contributing members. It is erroneously called "profits" or "dividends," when, in reality, it is only a return of unexpended assessments. When the system was new and untried, it was not thought prudent to make such restitution oftener than every five years. Gradually experience led to greater confidence, and competition introduced the practice of annual "dividends." These are principally derived from the higher rate of interest realized than the legal standard assumes, from a lower mortality than the table estimates, and from the excess of loading over actual expenses. Various ways of distributing this surplus have been in use, but the so-called "contribution plan," now universally adopted in the United States, is unquestionably the most equitable ever devised, as it returns to every member precisely his proportion of the over-payments. It may be best explained by an illustration.

Take a policy issued at 25, at an annual premium of $19.89, on which a cash dividend of $6.72 has been declared at the end of year 38. Assume the expenses applying to this policy to be equal to about 10 per cent. of the annual premium, the average rate of interest realized $5\frac{1}{2}$ per cent., and the actual mortality experience to be 10 per cent. less than the table indicates, the account would then stand as follows:

Reserve at the end of year 37			$101 51
Gross premium $19.89 paid at beginning of year 38, being net premium			13 42
Loading		$6 47	
Less actual expenses incurred		1 99	
			4 48
			$119 41
Interest earned at $5\frac{1}{2}$ per cent			6 57
			$125 98
Reserve at end of year 38		$111 74	
Cost of insurance according to table	$8 35		
Less saving by actual mortality (10 per cent.)	83		
		7 52	
			119 26
Return due on policy			$6 72

The same result may be shown in another way:

Legal reserve based on $4\frac{1}{2}$ per cent. interest, actually earned $5\frac{1}{2}$ per cent., being gain of 1 per cent. on $111.74	$1 12
Loading exceeds actual expenses	4 48
Interest on same at $5\frac{1}{2}$ per cent	25
Actual mortality less than assumed	83
Interest on same at $5\frac{1}{2}$ per cent	4
	$6 72

Of course, there may be other items of gain or loss besides those enumerated in the above illustration.

Most companies give policy-holders the option of either taking a cash return, or having the amount converted into a "reversionary dividend," payable with the policy; that is, simply to purchase insurance for a single premium. The above cash dividend of $6.72 would give a net reversionary dividend of $20.82 (the net single premium for $1.00 at age 39 being $0·32283); but of course some deduction must be made for expenses of management.

These reversionary additions form a very large item with old institutions, one leading company alone having over $25,000,000 in force.

Intimately connected with the reserves and dividends, and next in importance, is the question how lapsed or forfeited policies should be treated. Probably no theoretical point has been so hotly contested, and certainly none has offered equal difficulties in practice. In the early days of the institution, when it was prudent to err on the side of safety, the view prevailed that a policy was a contract for life, from which neither party could withdraw. Instead of a single premium in advance, annual account payments were accepted, but it was thought that a violation of this condition could only be regulated by absolute forfeiture of all previous contributions. As the business grew in importance, and long experience proved it grounded on reliable foundations, the harshness of this rule began to attract attention.

In England Dr. Farr advised the issuing of non-forfeitable policies, and the allowance of a definite cash surrender value on them. In this country the Insurance Commissioner of Massachusetts first brought the subject before the Legislature of that State, and a non-forfeiture law was passed in 1861. In opposition to the views held by actuaries of the old school, a tendency extreme in the other direction now began to assert itself. It was contended that the reserve pertaining to each policy should be considered equivalent to a deposit in a savings-bank, to be withdrawn at the pleasure of each individual insurer. This position was combated as wrong in theory, and as absolutely subversive of the business in practice. Insurance when applied to the individual becomes an absurdity, and it can only be safely conducted on averages dependent upon large aggregates. A person that insures for life virtually agrees to contribute to the death-claims of other members as long as he himself lives, and should he withdraw ought to pay his share of the liabilities assumed and the expenses of management attendant thereon. It becomes the duty of an insurance company to prevent the unnecessary withdrawal of its members, and self-preservation compels it to constantly strive to acquire new lives to retain the institution in a prosperous condition. Therefore, while it would be unjust to confiscate the whole accumulated reserve on lapsed policies,

it is but fair that such charge be made as to fully compensate the association for the loss of a withdrawing member.

These views may be considered as the equitable, middle course between two extreme positions, and they are now very generally conceded and adopted in practice. Policies are made non-forfeitable after two or three annual payments, and when lapsed, if presented within reasonable time, either paid-up insurance is granted or a percentage of the reserve allowed as cash surrender value. A few, indeed, have gone further, and printed in the contract the fixed cash surrender value that may be obtained at the end of every year. This innovation is not unlikely to be permanently ingrafted upon the business, and even now there is hardly a reputable company that declines to purchase its own policies when presented at the proper time; and the amounts thus expended are far greater than is generally known. One leading company of this State, whose annual premium income for 1879 was about $12,500,000, paid over $4,500,000 for surrendered policies. Various intricate formulas have been devised by actuaries to determine the strictly equitable surrender value, which, however, as far as the general reader is concerned, all culminate in a larger or smaller percentage of the reserve.

While proper agitation, competition, and a sense of justice, brought about a fair adjustment of cash surrender values, the question of paid-up insurance has been definitively determined in New York by the enactment of a statute, which went into effect January 1, 1880. It provides that when a policy shall lapse for the non-payment of premium, after being in force three years, the reserve and dividend additions on such policy shall, on demand made *within six months* after such lapse (unless the provisions of the statute had been specifically waived), be taken as a single premium at the published rates of the company, and be applied either to continue the policy in force at its *full amount*, so long as such single premium will purchase temporary insurance for that amount, or to purchase paid-up insurance, payable at the *same time* as the original insurance; provided, however, that the net value of the insurance given for such single premium shall in no case be less than two thirds of the entire reserve. That is to say, that the whole amount of the policy shall remain in force for such a length of time as no less than two thirds of the net reserve will purchase, or that the amount of the policy shall be reduced correspondingly, and be made to expire at the time originally fixed by the policy. In principle, therefore, the question may be considered as permanently settled, and new methods will certainly be devised to adjust minor practical difficulties upon an equitable basis.

Still, many crude ideas yet prevail among the insuring public, which lead to misunderstandings that ought not to exist. Some intelligent men, even, imagine that a company should be compelled to reinstate a lapsed policy without reëxamination of the insured life, or that, at

least, the whole amount of premiums paid ought to be returned, since no loss has occurred. However absurd such notions, they have caused much dissatisfaction, and, as they spring from a total misconception of the aims and functions of the institution, they ought to be dispelled. The companies themselves are not free from blame, however, for permitting many false impressions to gain ground. Nothing can be more mischievous than the assertion that life insurance is a profitable investment for money in the ordinary acceptation of that phrase. It is a provision against a contingency to which every human being is subject. A proper appreciation of its great benefits would prompt most men to seek its protection as far as their means permitted. To the majority of insurers, however, it is an actual expense, though allotted among them upon the most equitable basis. On the other hand, the amount of premiums paid can never be totally lost, since every life-policy must eventually become a death-claim. But only those should insure who really require it and can continue payments to the end. Had this always been understood, many policy-holders would have been spared disappointment and suffering when sober reaction followed a period of wild inflation.

One of the evils resulting from dissatisfaction with insurance companies has been the formation, all over the country, of so-called coöperative (latterly mutual benefit) life associations. They are based on what has already been shown as utterly impracticable—the collection of contributions on the death of members, with no fixed premiums or adequate accumulation of reserves. When the lives are newly selected, and not much above middle age, there is, at first, an appearance of saving over regular premiums. But, as they get older and the rate of mortality rises rapidly, the contributions become onerous, and, there being nothing to forfeit, the healthy lives withdraw, leaving a constantly increasing preponderance of impaired lives. The association breaks up, and those most in need of insurance can no longer obtain it from regular companies. The fallacy consists in assuming a continuous increase of new young lives that are willing to bear the burdens of the old members; an infatuation that never lasts long. It seems almost incredible that, in the face of well-established scientific principles and a century's experience, such crude experiments should again be introduced, as though they were a new invention. They deserve no better name than frauds, originated either by designing men to plunder the credulous or by those so grossly ignorant as to be no less culpable. Well have they merited the name current in insurance parlance, "the co-duperatives."

We have now touched upon most of the distinctive features of life insurance that interest the general reader, and but little remains to be said of the general management. It has been shown that next in importance to the collection of premiums is the accumulation of a reserve, which must earn at least the minimum rate of interest assumed as the

basis of calculation. This is no easy task in the present condition of the money market, and exceptional skill, prudence, and forethought, are required to secure safe and profitable investments. It must be remembered, too, that theoretically all the funds on hand are supposed to bring interest, while in practice a considerable part must always remain unemployed, so that the average rate realized is less than the current rate of interest. On the other hand, well-managed companies accumulate a surplus over the net reserve, and have their interest income largely increased from this source. Still more important is the fact, as far as New York is concerned, that, since Massachusetts and some other States have established four per cent. as the legal standard for reserve, and all companies desire to transact business in those States, they keep their surplus sufficiently high to be virtually on a four per cent. basis. Whether a lower rate than this will be realized on safe investments in the next quarter of a century, expert financiers and economists seem hardly prepared to answer; but, should a reduction to a three and a half per cent. standard become necessary, it would only temporarily incommode our sound offices.

With mortality tables as reliable as any human estimate can make them, and with reserves based on a sufficiently low rate of interest, the management of a life-insurance company does not materially differ from that of other moneyed institutions. The proper selection of business and the safe investment of funds require prudence and sagacity, and devolve great responsibility upon executive officers. But mutual-insurance companies (and nearly all stock companies in the United States also embody the mutual principle) have a margin far above any probable exigency, in the excessive loading of premiums. This very safeguard, it is true, may be perverted, and in some cases has been a temptation to abuse and extravagance. A life-insurance company once fairly established, however, ought to be as safe as any other financial institution, and, where failure occurs, it may always be traced to either gross mismanagement or intentional fraud. State supervision, which has been of great benefit to the system and to the community, can never supplant individual judgment or probity. In fact, it ought to be limited to prescribing minimum reserves, the character of investments, and the publication of truthful statements of the condition of companies.

While life insurance is of comparatively recent date in the United States (the oldest company now in business having been organized in 1843), its development has been so rapid as to have probably surpassed that of every other country. The following table shows the condition of the business, as reported to the New York department, in its infancy in 1859, its period of highest inflation in 1870, and at the lowest point of reaction in 1879:

1859.	No. of companies.	Number of policies.	Amount of insurance.	Gross assets.	Surplus.
New York State....	8	23,690	$72,197,426	$11,629,085	$3,630,706
Other States.......	6	25,918	69,300,541	8,907,000	1,440,442
	14	49,608	$141,497,967	$20,536,085	$5,071,148
1870.					
New York State....	41	377,437	$1,039,662,517	$133,119,187	$19,673,246
Other States.......	30	370,370	984,222,438	136,401,253	28,815,048
	71	747,807	$2,023,884,955	$269,520,440	$48,488,294
1879.					
New York State....	12	261,799	$730,648,500	$202,562,832	$32,887,465
Other States.......	19	333,687	709,312,665	198,952,961	32,390,256
	31	595,486	$1,439,961,165	$401,515,793	$65,277,721

The number of companies rose from fourteen to seventy-one in eleven years, and fell to thirty-one in the following nine years, while the amount insured was only reduced by about 25 per cent. Compared with other institutions, this shrinkage during a period of general retrenchment is not large. With about 600,000 policies in force, $400,000,000 of assets and $65,000,000 of net surplus, the success of life insurance is really astonishing. As a coöperative enterprise, in the truest sense of the word, it outranks every other in the means employed. Scientific principles are applied to the solution of an intricate social problem, and result in the most equitable division of burdens. The aims and purposes are most exalted, too. Other associations combine individuals to coöperate with a view to their own present support and immediate enjoyment, while this institution is based upon abstention, self-imposed for other future beneficiaries.

With its usefulness not yet fully appreciated, its wide field of application not thoroughly understood, we may well be thankful for what it has already accomplished, and be proud of it as an exponent of the civilization and of the times in which we live.

HOW THE EARTH IS WEIGHED.

By Dr. OTTO WALTERHÖFER.

EFFORTS have been made, at all times in which the spirit of investigation can be said to have existed, to ascertain the condition of the interior of the earth. There has been no lack of unfounded assumptions on the subject, and fanciful hypotheses were held even down to a period in which correct conclusions had been reached upon

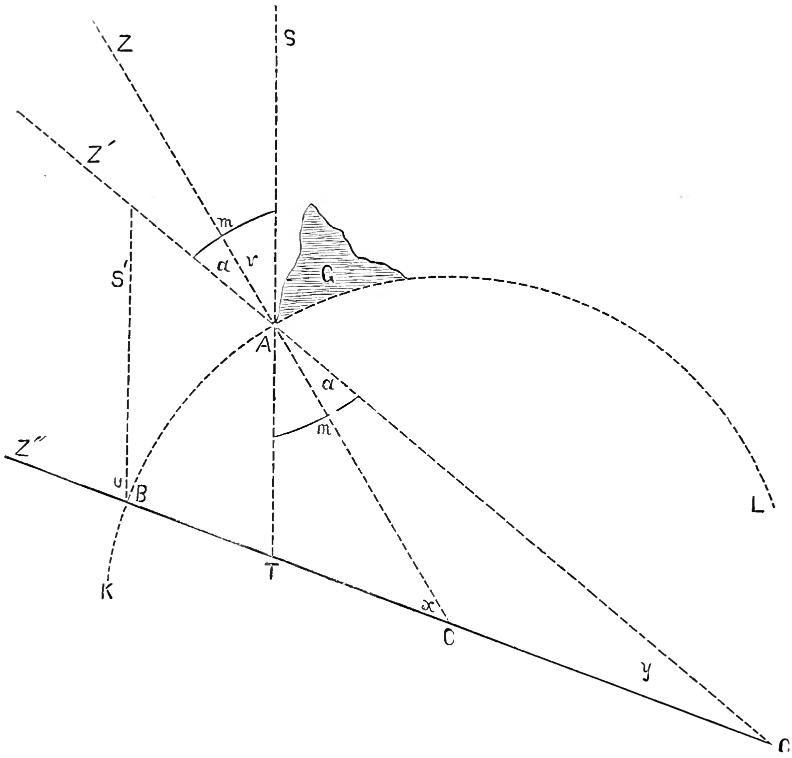
it—to the beginning of the nineteenth century. Alexander von Humboldt relates that he and Sir Humphry Davy were several times invited by Captain Symmes to join an expedition into the interior of the earth, which was represented as a hollow sphere having a large opening at the eighty-second parallel of north latitude. The idea of the existence of a hollow space within the earth was set at rest by the measurement of the average density of the planet, and the contrary view was advanced that the globe is a mass of great specific gravity. The constituency of this mass, whether it is fluid or solid, with only local bubble-like spaces, filled with fluid matter, has not been determined; but the calculations that have been made contradict the theory of a wholly fluid interior.

Several methods have been adopted for ascertaining the mean density of the earth, to the older of which a more accurate method has been added within a few years. An account of the methods hitherto adopted, and the results obtained by them, is here given.

Determination from the Deflection of the Plumb-Line.—Newton first suggested that the specific gravity of the earth could be ascertained by means of the plumb-line, but he made no effort to apply his suggestion. The thought was a sequence of his law of gravitation, on which all the methods that have been employed have been based. That law declares that all bodies exert an attractive force upon each other in direct proportion to their masses and in inverse proportion to the square of the distance of their centers of gravity from each other. Accordingly, a body hanging by a line, which over a level surface would be drawn by the earth's attraction into a direction with reference to its point of suspension, the prolongation of the line of which would pass through the center of the earth—that is, would be perpendicular, or plumb—would be attracted and turned away from the perpendicular by a mass like a mountain in the neighborhood. If, now, the amount of this diversion and the size of the mass exercising the deflecting influence were known, then the mass of the earth, and from this in connection with the shape and size of the earth, its mean density, could be computed. The diversion of the plummet from its perpendicular direction is, however, too minute to make a direct measurement possible, and the following method has, therefore, been adopted: In Fig. 1, let K L be a part of the surface of the earth, and G an isolated mountain. A plumb-line at the point A, at the foot of the mountain, and one at B, several miles from it, would take such directions in case the earth were a perfect sphere that the prolongation of the lines would intersect each other at the center of the earth, and form the angle x, with the sides C Z and C Z″, Z and Z″ representing the zeniths at A and B. The zenith-distance v, of any suitable fixed star S, in the neighborhood of Z, may be easily obtained by direct measurement. Let also the zenith-distance of the same star at the point B, which is equivalent to the angle u, be determined. The lines

A S and B S′, representing the direction of the star S, as seen from the points A and B, may, in consequence of the immense distance of the star from the earth, be regarded as parallel. On account of the proximity of the mountain G, the plumb-line does not take the direction

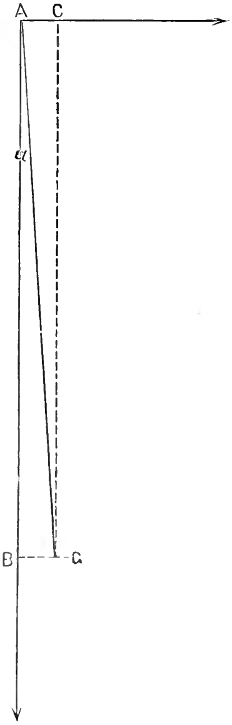
FIG. 1.



A Z, but is deflected toward the mountain, so that it gives the direction A Z′ as the apparent vertical, and Z′ as the apparent zenith. On this account, the zenith-distance of the star is increased by the angle a, to a degree that is represented by the angle m. The prolonged plumb-lines B Z″ and A Z′ consequently do not form the angle x at the center of the earth, but another angle, y, which differs from x by the magnitude a, wherefore, $a = x - y$. If, now, we imagine the line of direction A S prolonged backward, an equivalent of the angle u is formed at T, and by the lines A C′ and A T the angle m, equal to the observed zenith-distance at A. But u being the external angle of a triangle, $= m - y$, or $y = m - u$; and since a is equal to $x - y$, if we substitute for y the difference $m - u$, $a = x + u - m$. The angles u and m have been obtained by observation as zenith-distances of the fixed star S S′, and we have only to obtain the value of the angle x, which is deduced from a trigonometrical measurement of the arc A B. The mass of the

mountain which diverts the lead is found by a calculation of its form, magnitude, and density, and the mean density of the earth is afterward obtained by a calculation based upon the following data: Let A C (Fig. 2) represent the amount and direction of the attraction which the mountain exercises on the plummet, A B that of the earth upon the same; then A G represents the resultant attraction to which the lead is subjected. If, further, we make R represent the distance of the earth's center, and r that of the center of gravity of the mountain, from the lead, and M and m respectively, the masses of the earth and of the mountain, then we have, according to the law of attraction, $\frac{M}{R^2} : \frac{m}{r^2} :: A B : A C$, or since $A C = B G$, $\frac{M}{R^2} : \frac{m}{r^2} :: A B : B G$. From this proportion the mass and density of the earth are deduced by a series of mathematical formulas which it is not necessary to give in detail here.

Fig. 2.



Proceeding by this method, Maskelyne and Hutton undertook, between 1774 and 1776, the first efforts to estimate the specific gravity of the earth. They conducted their experiments near Mount Shehallien in Perthshire, Scotland, and found that the lead was deflected by the mountain to the amount of fifty-three seconds, whence they calculated the mean density of the earth to be 4·7. Making use of the observations of these two philosophers, Playfair and Seymour, after corrected calculations of the density of Shehallien, obtained a mean density of 4·7113.

Although no theoretical objections can be offered to the manner in which these observations were applied, great exactness can not be claimed for the results, because the calculations of the mass of the mountain, of its mean density, and of the distance of its center of gravity from the lead, were based on estimates, and liable to errors.

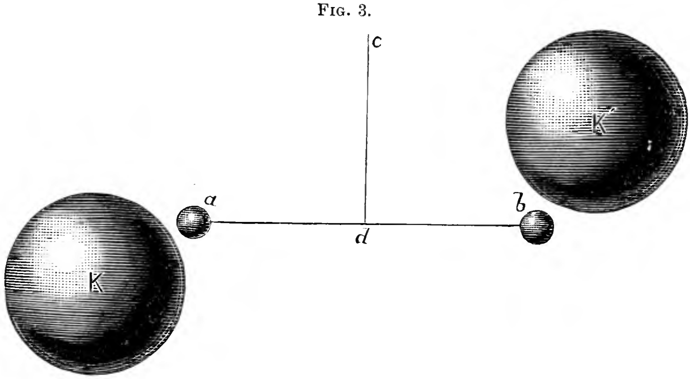
Determination by Means of the Pendulum.—A pendulum which is forced out of the vertical direction tends to resume it as soon as the deflecting force is removed. Its momentum carries it beyond the vertical position, and it therefore swings back and forth in times proportionate to its length. The durations of single oscillations of the same pendulum may be considered to be equal to each other if the departure from the vertical does not exceed five degrees. The cause of the oscillations is gravity, or the attractive power of the earth. Since this force diminishes as the square of the distance from the earth's center increases, its amount at different elevations above

the surface may be exactly calculated. The time required for the vibration of the pendulum is, in consequence of the same law, longer at heights above, shorter at points below the surface of the earth, than at the surface itself; hence it is easy to calculate the time of an oscillation at any given elevation. It is necessary, however, in order that the time calculated in this manner may agree with the result actually observed, that the surface of the earth at the given point shall be plane, and form part of an exact sphere. Mountains near the place of observation cause the attraction on the ball to be stronger than is contemplated in the calculation, and make the oscillations more rapid. The difference between the calculated and observed rate of oscillation will give the amount of influence which the mountain exerts. From this, the relative masses of the mountain and the earth being known, the mean density of the earth may be calculated by a series of formulas similar to those by which it is computed in the method just described. This method is liable to the same defects as the former one; that is, that the elements of the mountain on which the calculations are based are estimated, not accurately measured.

Carlini, Biot, and Matthieu employed it in 1824, Carlini selecting Mont Cenis as his point of observation, the other philosophers performing their experiments at Bordeaux. Their calculations gave a mean density of 4·83. Two other philosophers, Julius and E. Schmidt, calculating from the same observations, obtained, the former 4·95, the latter 4·84. Adopting a converse method from that of Carlini, Drobish, in 1826, measured the duration of the oscillations of the pendulum in a mining-shaft at Dolcoath, in Cornwall, and obtained 5·43.

Determination by Means of the Torsion Balance.—The torsion balance employed in measuring the density of the earth consists

Fig. 3.



of a straight rod *a b* (Fig. 3) of as uniform dimensions as possible, made of wood or metal, hanging by the cord *c d*, and supporting at its ends the balls *a* and *b*. A small mirror at *d*, in the middle of the

rod, on which a perpendicular beam of light is made to fall, indicates, by means of a graduated circle engraved upon it, the most minute horizontal deflections of the balance. Two leaden balls, K and K', are brought within a suitable distance of the balls a and b, exercise an attractive force upon them, and cause an horizontal deflection of the balance, in a direction opposed to the torsion force of the cord, the value of which may be ascertained by measurement. From this value is computed the force of the attraction which the leaden masses K and K' exercise upon a and b. Since the masses of the four balls, their relative distances from each other, and the amount of the attraction exerted upon them by the earth (which is given by the absolute weight of the balls), are all measurable, the ratio of the mass of the earth to the masses of the balls K and K' can be calculated, and from this, by the process already given, the mean density of the earth.

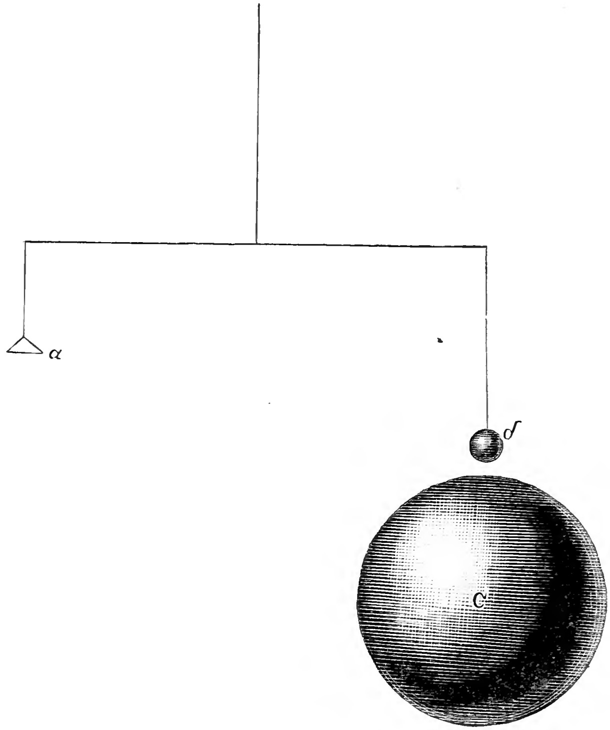
The results obtained by this method have a considerable degree of trustworthiness, for clear determinations are obtained in which errors are possible only in a small degree. The method was used by Cavendish in 1798, whose calculations gave 5·48, by Reich in Freiberg in 1837, who obtained 5·44, and by Baily in 1842, who obtained 5·6747. Reich repeated his experiments with improved apparatus between 1847 and 1850, using tin balls instead of leaden ones, and twisted copper wires or double iron wires instead of cord, and obtained 5·5756, a value which is often written briefly as 5·58. Hutton calculated the specific gravity of the earth from Cavendish's observations at 5·32, and E. Schmidt at 5.52.

Determination by Means of the Two-Armed Balance.—The idea of using the balance as means of measuring the mean density of the earth originated with the physicist Jolly, who suggested its application to this purpose in describing some improvements he had made in the instrument to increase its sensitiveness. The application was made by H. Poynting, in Manchester, who adopted the following method: Instead of a scale, he attached a weight (b Fig. 4), of 452·92 grammes to the end of a rod six feet in length, to which he opposed a counter-weight in the scale at the other end of the balance; a ball, C, weighing 154·220·6 grammes was brought to a position perpendicularly under b, when the mutual attraction of the two bodies occasioned a disturbance of the balance to the amount of 0·01 of a milligramme. The weight of the two mutually attracting bodies and the amount of attraction exerted upon them by the earth being known, and the distance apart of their centers of gravity having been carefully measured, Poynting calculated the mean density of our planet at 5·69, with a probable error of 0·15.

The approximate agreement of the results obtained by these four methods authorizes us to conclude that the masses of the interior of the earth possess a great density. If we consider, with Alexander von

Humboldt, that the dry continental parts of the crust of the earth have a mean density of from 2·4 to 2·6, and the dry and oceanic parts of 1·5, and accept Reich's later estimate of the mean total density at 5·58, then the inaccessible, internal parts of the earth must have a

FIG. 4.



mean specific weight of 9·66. Only the metals among the bodies in the accessible parts of the earth possess so great a density; we have a right, then, to believe that the nucleus of the earth possesses a metallic constitution.

The density of the other heavenly bodies is deduced from that of the earth, by observing the amount of attraction which two bodies exert upon each other, and upon a third, and, having ascertained the distances apart of the three bodies, calculating their mutual densities by approved mathematical formulas.—*Die Natur.*

THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

By HERBERT SPENCER.

X.—THE MILITANT TYPE OF SOCIETY.

PRECEDING chapters have prepared the way for framing conceptions of the two fundamentally-unlike kinds of political organization, proper to the militant life and the industrial life, respectively. It will be instructive here to arrange in coherent order those traits of the militant type already incidentally marked, and to join with them various dependent traits; and in the next chapter to deal in like manner with the traits of the industrial type.

During social evolution there has habitually been a mingling of the two. But we shall find that, alike in theory and in fact, it is possible to trace out with due clearness those opposite characters which distinguish them in their respective complete developments. Especially is the essential nature of the organization which accompanies chronic militancy capable of being inferred *a priori*, and proved *a posteriori* to exist in numerous cases, while the essential nature of the organization accompanying pure industrialism, of which at present we have little experience, will be made clear by opposition, and such illustrations as exist of progress toward it will become recognizable.

In drawing conclusions, two liabilities to error must be guarded against. We have to deal with societies compounded and recompounded in various degrees; and we have to deal with societies which, differing in their stages of culture, have their organizations elaborated to different extents. We shall be misled, therefore, unless our comparisons are such as take account of unlikenesses in size and in civilization. Clearly, characteristics of the militant type which admit of being displayed by a vast nation may not admit of being displayed by a horde of savages, though this is equally militant. Moreover, as institutions take a long time to acquire their finished forms, it is not to be expected that all militant societies will display the structure appropriate to them in its completeness. Rather may we expect that in most cases it will be incompletely displayed.

In face of these difficulties the best course will be to consider, first, what are the several traits which of necessity militancy tends to produce; and then to observe how far these traits are conjointly shown in past and present nations distinguished by militancy. Having contemplated the society ideally organized for war, we shall be prepared to recognize in real societies the character which war has brought about.

For preserving its corporate life, a society is impelled to corporate action; and the preservation of its corporate life is the more probable

in proportion as its corporate action is the more complete. For purposes of offense and defense, the forces of individuals have to be combined; and, where every individual contributes his force, the probability of success is greatest. Numbers, natures, and circumstances being equal, it is clear that of two tribes or two larger societies, one of which unites the actions of all its capable members while the other does not, the first will ordinarily be the victor. There must be an habitual survival of communities in which militant coöperation is universal.

This proposition approaches very nearly to a truism. But it is needful here, as a preliminary, clearly to recognize the truth that the social structure evolved by chronic militancy is one in which all men fit for fighting act in concert against other societies. Such further actions as they carry on they can carry on separately; but this action they must carry on jointly.

A society's power of self-preservation will be great in proportion as, besides the direct aid of all who can fight, there is given the indirect aid of all who can not fight. Supposing them otherwise similar, those communities will survive in which the efforts of combatants are in the greatest degree seconded by those of non-combatants. In a purely militant society, therefore, individuals who do not bear arms have to spend their lives in furthering the maintenance of those who do. Whether, as happens at first, the non-combatants are exclusively the women; or whether, as happens later, the class includes enslaved captives; or whether, as happens later still, it includes serfs, the implication is the same. For, if, of two societies equal in other respects, the first wholly subordinates its workers in this way, while the workers in the second are allowed to retain for themselves the produce of their labor, or more of it than is needful for maintaining them, then, in the second, the warriors, not otherwise supported or supported less fully than they might else be, will have partially to support themselves, and will be so much the less available for war purposes. Hence, in the struggle for existence between such societies, it must usually happen that the first will vanquish the second. The type of society produced by survival of the fittest will be one in which the fighting part includes all who can bear arms and be trusted with arms, while the remaining part serves simply as a parmanent commissariat.

An obvious implication, of a significance to be hereafter pointed out, is that the non-combatant part, occupied in supporting the combatant part, can not with advantage to the self-preserving power of the society increase beyond the limit at which it efficiently fulfills its purpose. For, otherwise, some who might be fighters are superfluous workers; and the fighting power of the society is made less than it might be. Hence, in the militant type, the tendency is for the body of warriors to bear the largest practicable ratio to the body of workers.

Given two societies of which the members are all either warriors or those who supply the needs of warriors, and, other things equal, supremacy in war will be gained by that in which the efforts of all are most effectually combined. In open warfare joint action triumphs over individual action. Military history is a history of the successes of men trained to move and fight in concert.

Not only must there be in the fighting part a combination such that the powers of its units may be concentrated, but there must be a combination of the subservient part with it. If the two are so separated that they can act independently, the needs of the fighting part will not be adequately met. If to be cut off from a temporary base of operations is dangerous, still more dangerous is it to be cut off from the permanent base of operations—namely, that constituted by the body of non-combatants. This has to be so connected with the body of combatants that its services may be fully available. Evidently, therefore, development of the militant type involves a close binding of the society. As the loose group of savages yields to the solid phalanx, so, other things equal, must the society of which the parts are but feebly held together yield to one in which they are held together by strong bonds.

But, in proportion as men are compelled to coöperate, their self-prompted actions are restrained. By as much as the unit becomes merged in the mass, by so much does he lose his individuality as a unit. And this leads us to note the several ways in which evolution of the militant type entails subordination of the citizen.

His life is not his own, but is at the disposal of his society. So long as he remains capable of bearing arms he has no alternative but to fight when called upon; and, where militancy is extreme, he can not return as a vanquished man under penalty of death.

Of course with this there goes possession of such liberty only as military obligations allow. He is free to pursue his private ends only when the society has no need of him; and, when it has need of him, his actions from hour to hour must conform, not to his own will, but to the public will.

So, too, with his property. Whether, as in many cases, what he holds as private he so holds by permission only, or whether private ownership is recognized, it remains true that in the last resort he is obliged to surrender whatever is demanded for public use.

Briefly, then, under the militant type the individual is owned by the state. While preservation of the society is the primary end, preservation of each member is a secondary end—an end cared for chiefly as subserving the primary end.

Fulfillment of these requirements, that there shall be complete corporate action, that to this end the non-combatant part shall be

occupied in providing for the combatant part, that the entire aggregate shall be strongly bound together, and that the units composing it must have their individualities in life, liberty, and property, thereby subordinated, presupposes a coercive instrumentality. No such union for corporate action can be achieved without a powerful controlling agency. On remembering the fatal results caused by division of counsels in war, or by separation into factions in face of an enemy, we see that chronic militancy tends to develop a despotism; since, other things equal, those societies will habitually survive in which, by its aid, the corporate action is made more complete.

And this involves a system of centralization. The trait made familiar to us by an army, in which, under a commander-in-chief, there are secondary commanders over large masses, and under these tertiary ones over smaller masses, and so on down to the ultimate divisions, must characterize the social organization at large. A militant society must have a regulative structure of this kind, since otherwise its corporate action can not be made most effectual. Without such grades of governing centers diffused throughout the non-combatant part as well as the combatant part, the entire forces of the aggregate can not be promptly put forth. Unless the workers are under a control akin to that which the fighters are under, their indirect aid can not be insured in full amount and with due quickness.

And this is the form of a society characterized by *status*—a society, the members of which stand one toward another in successive grades of subordination. From the despot down to the slave, all are masters of those below and subjects of those above. The relation of the child to the father, of the father to some superior, and so on up to the absolute head, is one in which the individual of lower status is at the mercy of one of higher status.

Otherwise described, the process of militant organization is a process of regimentation, which, primarily taking place in the army, secondarily affects the whole community.

The first indication of this we trace in the fact everywhere visible, that the military head grows into a civil head—mostly at once, and, in exceptional cases, at last, if militancy continues. Beginning as leader in war he becomes ruler in peace; and such regulative policy as he pursues in one sphere, he pursues, so far as conditions permit, in the other. Being, as the non-combatant part is, a permanent commissariat, the principle of graduated subordination is extended to it. Its members come to be directed in a way like that in which the warriors are directed—not literally, since the dispersion of the one and the concentration of the other prevent exact parallelism; but, nevertheless, similarly in principle. Labor is carried on under coercive control; and supervision spreads everywhere.

To suppose that a despotic military head, carrying out daily the

inherited traditions of regimental control as the sole form of government known to him, will not impose on the producing classes a kindred control, is to suppose in him sentiments and ideas entirely foreign to his circumstances.

The nature of the militant form of government will be further elucidated on observing that it is both positively regulative and negatively regulative. It does not simply restrain; it also enforces. Besides telling the individual what he shall not do, it tells him what he shall do.

That the government of a fighting body is thus characterized needs no showing. Indeed, commands of the positive kind given to the soldier are more important than those of the negative kind: fighting is done under the one, while order is maintained under the other. But here it chiefly concerns us to note that not only the control of military life, but also the control of civil life, is, under the militant type of government, thus characterized. There are two ways in which the ruling power may deal with the private individual. It may simply limit his actions to those which he can carry on without aggression, direct or indirect, upon others; in which case its action is negatively regulative. Or, besides doing this, it may prescribe the how, and the where, and the when, of his daily actions; may force him to do various things which he would not spontaneously do; may direct in greater or less detail his mode of living; in which case its action is positively regulative. Under the militant type this positively regulative action is widespread and peremptory. The civilian is in a condition as much like that of the soldier as difference of occupation permits.

And this is another way of expressing the truth that the fundamental principle of the militant type is compulsory coöperation. While this is obviously the principle under which the members of the combatant body act, it no less certainly must be the principle acted upon throughout the non-combatant body, if military efficiency is to be great; since, otherwise, the aid which the non-combatant body has to furnish can not be insured.

That binding together by which the units of a militant society are made into an efficient fighting structure tends to fix the position of each in rank, in occupation, in locality.

In a graduated regulative organization there is resistance to change from a lower to a higher grade. Such change is made difficult by lack of the possessions needed for filling superior positions; and it is made difficult by the opposition of those who already fill them, and can hold inferiors down. Preventing intrusion from below, these transmit their respective places and ranks to their descendants; and, as the principle of inheritance becomes settled, the rigidity of the social structure becomes decided. Only where an "egalitarian despotism" reduces all

subjects to the same political status—a condition of decay rather than of development—does the converse state arise.

The principle of inheritance, becoming established in respect of the classes which militancy originates, and fixing the general functions of their members from generation to generation, tends eventually to fix also their special functions. Not only do men of the slave classes and the artisan classes succeed to their respective positions, but they succeed to the particular occupations carried on in them. This, which is a working out of the tendency toward regimentation, is ascribable primarily to the fact that superiors, requiring from each kind of worker his particular product, have an interest in replacing him at death by a capable successor; while he, prompted to get aid in fulfilling of his tasks, has an interest in bringing up a son to his own occupation: the will of the son being powerless against these conspiring interests. Under the system of compulsory coöperation, therefore, the principle of inheritance, spreading through the producing organization, causes a relative rigidity in this also.

And then a kindred effect is shown in the entailed restraints on movement from place to place. In proportion as the individual is subordinated in life, liberty, and property, to his society, it is needful that his whereabout shall be constantly known. Obviously the relation of the soldier to his officer, and of this officer to his superior, is such that each must be ever at hand; and where the militant type is fully developed the like holds throughout the society. The slave can not leave his appointed abode; the serf is tied to his allotment; the master is not allowed to absent himself from his locality without leave.

So that the corporate action, the combination, the cohesion, the regimentation, which efficient militancy necessitates, imply a structure which strongly resists change.

A further trait of the militant type, naturally accompanying the last, is that organizations other than those forming parts of the state organization are wholly or partially repressed. The public combination occupying all fields, excludes private combinations.

For the achievement of complete corporate action, there must, as we have seen, be a centralized administration, not only throughout the combatant part, but throughout the non-combatant part; and, if there exist unions of citizens which act independently, they in so far diminish the range of this centralized administration. Any structures which are not parts of the state structure serve more or less as limitations to it, and stand in the way of the required unlimited subordination. If private combinations are allowed to exist, it will be on condition of submitting to an official regulation such as greatly restrains independent action; and since private combinations thus officially regulated are inevitably hindered from doing things not conforming to established routine, and are so debarred from improvement,

they can not habitually thrive and grow. Obviously, indeed, such combinations, formed on the principle of voluntary coöperation, are incongruous with the social type formed on the principle of compulsory coöperation. Hence the militant type is characterized by the absence, or comparative rarity, of bodies of citizens associated for commercial purposes, for propagating special religious views, for achieving philanthropic ends, etc.

Private combinations of one kind, however, are congruous with the militant type—the combinations, namely, which are formed for minor defensive or offensive purposes. We have, as examples, those which constitute factions, very general in militant societies; those which assume forms like the primitive guilds, serving for mutual protection; and those which take the shape of secret societies. Of such bodies it may be noted that they fulfill on a small scale ends like those which the whole society fulfills on a large scale—the ends of self-preservation, or aggression, or both. And it may be further noted that these small included societies are organized on the same principle as the large including society—the principle of compulsory coöperation. Their governments are coercive: in some cases even to the extent of killing those of their members who are disobedient.

A remaining fact to be noted is that a society of the militant type tends to evolve a self-sufficient sustaining organization. With its political autonomy there goes what we may call an economic autonomy. Evidently in proportion as it carries on frequent hostilities with surrounding societies, its commercial intercourse with them must be hindered or prevented: exchange of commodities can go on but to a slight extent between those who are continually fighting. A militant society must, therefore, to the greatest degree practicable, provide internally the supplies of all articles needful for carrying on the lives of its members. Such an economic state as that which existed during early feudal times, when, as in France, "the castles made almost all the articles used in them," is a state evidently entailed on groups, small or large, which are in constant antagonism with surrounding groups. If there does not already exist, within any group so circumstanced, an agency for producing some necessary article, inability to obtain it from without will lead to the establishment of an agency for obtaining it within.

Whence it follows that the desire "not to be dependent on foreigners" is one appropriate to the militant type of society. So long as there is danger that the supplies of needful things derived from other countries will be cut off by the breaking out of hostilities, it is imperative that there shall be maintained a power of producing these supplies at home, and that to this end the required structures shall be maintained. Hence there is a manifest direct relation between militant activities and a protectionist policy.

And now having noted the traits which may be expected to establish themselves by survival of the fittest during the struggle for existence among societies, let us observe how these traits are displayed in actual societies, similar in respect of their militancy but otherwise dissimilar.

Of course in small primitive groups, however warlike they may be, we must not look for more than rude outlines of the structure proper to the militant type. Being loosely aggregated, definite arrangement of their parts can be carried but to a small extent. Still, so far as it goes, the evidence is to the point. The fact that habitually the fighting body is coextensive with the adult male population is so familiar that no illustrations are needed. An equally familiar fact is that the women, occupying a servile position, do all the unskilled labor and bear the burdens; with which may be joined the fact that not unfrequently during war they carry the supplies, as in Asia among the Bhils and Khonds, as in Polynesia among the New Caledonians and Sandwich-Islanders, as in America among the Comanches, Mundrucus, Patagonians: their office as forming the permanent commissariat being thus clearly shown. We see, too, that, where the enslaving of captives has arisen, these also serve to support and aid the combatant class; acting during peace as producers and during war joining the women in attendance on the army, as among the New-Zealanders, or, as among the Malagasy, being then exclusively the carriers of provisions, etc. Again, in these first stages, as in later stages, we are shown that private claims are, in the militant type, overridden by public claims. The life of each man is held subject to the needs of the group; and, by implication, his freedom of action is similarly held. So, too, with his goods; as instance the remark made of the Brazilian Indians, that personal property, recognized but to a limited extent during peace, is scarcely at all recognized during war; and as instance Hearne's statement concerning certain hyperborean tribes of North America when about to make war, that "property of every kind that could be of general use now ceased to be private." To which add the cardinal truth, once more to be repeated, that where no political subordination exists war initiates it. Tacitly or overtly a chief is temporarily acknowledged; and he gains permanent power if war continues. From these beginnings of the militant type which small groups show us, let us pass to its developed forms as shown in larger groups.

"The army, or, what is nearly synonymous, the nation of Dahomey," to quote Burton's words, furnishes us with a good example: the excessive militancy being indicated by the fact that the royal bedroom is paved with skulls of enemies. Here the king is absolute, and is regarded as supernatural in character—he is "the spirit"; and of course he is the religious head—he ordains the priests. He absorbs in himself all powers and all rights: "by the state law of Dahomey. . . all men are slaves to the king." He "is heir to all his subjects"; and

he takes from living subjects whatever he likes. When we add that there is a frequent killing of victims to carry messages to the other world, as well as occasions on which numbers are sacrificed to supply deceased kings with attendants, we are shown that life, liberty, and property are at the entire disposal of the state as represented by its head. In both the civil and military organizations the centers and subcenters of control are numerous. Names, very generally given by the king and replacing surnames, change "with every rank of the holder"; and so detailed is the regimentation that "the dignities seem interminable." There are numerous sumptuary laws; and, according to Waitz, no one wears any other clothing or weapons than what the king gives him or allows him. Under penalty of slavery or death "no man must alter the construction of his house, sit upon a chair, or be carried on a hammock, or drink out of a glass," without permission of the king.

The ancient Peruvian empire, gradually established by the conquering Incas, may next be instanced. Here the ruler, divinely descended, sacred, absolute, was the center of a system which minutely controlled all life. His headship was at once military, political, ecclesiastical, judicial; and the entire nation was composed of those who, in the capacity of soldiers, laborers, and officials, were slaves to him and his deified ancestors. Military service was obligatory on all taxable Indians who were capable; and those of them who had served their prescribed terms, formed into reserves, had then to work under state superintendence. The army having heads of ten, fifty, a hundred, five hundred, a thousand, ten thousand, had, besides these, its superior commanders of Inca blood. The community at large was subject to a parallel regimentation: the inhabitants, registered in groups, being under the control of officers over tens, fifties, hundreds, and so on. And through these successive grades of centers reports ascended to the Inca governors of great divisions, passing on from them to the Inca; while his orders descended "from rank to rank till they reached the lowest." There was an ecclesiastical organization, similarly elaborate, having, for example, five classes of diviners; and there was an organization of spies to examine and report upon the doings of the other officers. Everything was under public inspection. There were village officers who overlooked the plowing, sowing, and harvesting. When there was a deficiency of rain, measured quantities of water were supplied by the state. Any who traveled without authority were punished as vagabonds; but, for those who were authorized to travel for public purposes, there were establishments supplying lodging and necessaries. "It was the duty of the decurions to see that the people were clothed"; and the kinds of cloth, decorations, badges, etc., to be worn by the different ranks were all prescribed. Besides this regulation of external life, there was regulation of domestic life. The people were required to "dine and sup with open doors, that the judges

might be able to enter freely"; and these judges had to see that the house, clothes, furniture, etc., were kept clean and in order, and the children properly disciplined: those who mismanaged their houses being flogged. Subject to this regulation, the people labored to support this elaborate state organization. The political, religious, and military classes, throughout all their grades, were exempt from tribute, while the laboring classes, when not serving in the army, had to yield up all produce beyond that required for their bare sustenance. Of the whole empire, one third was allotted for supporting the state, one third for supporting the prisethood, who ministered to the manes of ancestors, and the remaining third had to support the workers. Besides giving tribute by tilling the lands of the sun and the king, the workers had to till the lands of the soldiers on duty, as well as those of the incapables. And they had also to pay tribute of clothes, shoes, and arms. Of the lands on which the people maintained themselves, the parts were apportioned to each man according to the size of his family. Similarly with the produce of the flocks. Such moiety of this in each district as was not required for supplying public needs was periodically shorn, and the wool divided by officials. These arrangements were in pursuance of the principle that "the private property of each man was held by favor of the Inca, and according to their laws he had no other title to it." Thus the people, completely possessed by the state in person, property, and labor, transplanted to this or that locality, as the Inca directed, and, when not serving in the army, living under a discipline like that within the army, were units in a centralized regimented machine, moved throughout life to the greatest practicable extent by the Inca's will, and to the least practicable extent by their own wills. And, naturally, along with militant organization thus carried to its ideal limit, there went an almost entire absence of any other organization. They had no money; "they neither sold clothes nor houses nor estates"; and trade was represented among them by scarcely anything more than some bartering of articles of food.

So far as accounts of it go, ancient Egypt presents us with phenomena allied in their general if not in their special characters. Its predominant militancy during its remotest unrecorded times is sufficiently implied by the vast population of slaves who toiled to build the pyramids; and its subsequent continued militancy we are shown alike by the boasting records of its kings, and the delineations of their triumphs on its temple-walls. Along with this form of activity we have, as before, the god-descended ruler, limited in his powers only by the usages transmitted from his divine ancestors, who was at once political head, high-priest, commander-in-chief, and supreme judge. Under him was a centralized organization, of which the civil part was arranged in classes and sub-classes as definite as were those of the militant part. Of the four great social divisions—priests, soldiers, townsmen, or traders, and common people, beneath whom came the slaves—

the first contained more than a score of different orders; the second some half-dozen beyond those constituted by military grades; the third nearly a dozen; and the fourth a still greater number. Though within the ruling classes the castes were not so rigorously defined as to prevent change of function in successive generations, yet Herodotus and Diodorus state that industrial occupations descended from father to son; "every particular trade and manufacture was carried on by its own craftsmen, and none changed from one trade to another." How elaborate was the regimentation may be judged from the detailed account of the staff of officers and workers engaged in one of their vast quarries: the numbers and kinds of functionaries paralleling those of an army. To support this highly-developed regulative organization, civil, military, and sacerdotal—an organization which held exclusive possession of the land—the lower classes labored. "Overseers were set over the wretched people, who were urged to hard work more by the punishment of the stick than words of warning." And whether or not official oversight included domiciliary visits, it at any rate went to the extent of taking note of each family. "Every man was required under pain of death to give an account to the magistrate of how he earned his livelihood."

Take now another ancient society, which, contrasted in sundry respects, shows us, along with habitual militancy, the assumption of structural traits allied in their fundamental characters to those thus far observed. I refer to Sparta. That warfare did not among the Spartans evolve a simple despotic head, while in part due to causes which, as before shown, favor the development of compound political heads, was largely due to the accident of their double kingship: the presence of two divinely-descended chiefs prevented the concentration of power. But though from this cause there continued an imperfectly centralized government, the relation of this government to members of the community was substantially like that of militant governments in general. Notwithstanding the serfdom, and in towns the slavery of the Helots, and notwithstanding the political subordination of the Periœki, they all, in common with the Spartans proper, were under obligation to military service: the working function of the first, and the trading function, so far as it existed, which was carried on by the second, were subordinate to the militant function with which the third was exclusively occupied. And the civil divisions thus marked reappeared in the military divisions: "At the battle of Platæa every Spartan hoplite had seven Helots, and every Periœki hoplite one Helot to attend him." The extent to which, by the daily military discipline, prescribed military mess, and fixed contributions of food, the individual life of the Spartan was subordinated to the public demands from seven years upward, needs mention only to show the rigidity of the restraints which here, as elsewhere, the militant type imposes—restraints which were further shown in the prescribed age for marriage, the prevention

of domestic life, the forbidding of industry or any money-seeking occupation, the interdict of going abroad without leave, and the authorized censorship under which his days and nights were passed. There was fully carried out in Sparta the Greek theory of society, that "the citizen belongs neither to himself nor to his family, but to his city." So that though in this exceptional case chronic militancy was prevented from developing a supreme head, owning the individual citizen in body and estate, yet it developed an essentially identical relation between the community as a whole and its units. The community, exercising its power through a compound head instead of through a simple head, completely enslaved the individual. While the lives and labors of the Helots were devoted exclusively to the support of those who formed the militant organization, the lives and labors of those who formed the militant organization were exclusively devoted to the service of the state—they were slaves with a difference.

Of modern illustrations that furnished by Russia will suffice. Here, again, with the wars which effected conquests and consolidations, came the development of the victorious commander into the absolute ruler, who, if not divine by alleged origin, yet acquired something like divine *prestige*. "All men are equal before God, and the Russian's God is the Emperor," says De Custine ; "the supreme governor is so raised above earth that he sees no difference between the serf and the lord." Under the stress of Peter the Great's wars, which, as the nobles complained, took them away from their homes, "not, as formerly, for a single campaign, but for long years," they became "the servants of the state, without privileges, without dignity, subjected to corporal punishment, and burdened with onerous duties from which there was no escape. . . . Any noble who refused to serve ('the state in the army, the fleet, or the civil administration, from boyhood to old age') was not only deprived of his estate, as in the old times, but was declared to be a traitor, and might be condemned to capital punishment." "Under Peter," says Wallace, "all offices, civil and military," were "arranged in fourteen classes or ranks" ; and he "defined the obligations of each with microscopic minuteness. After his death the work was carried on in the same spirit, and the tendency reached its climax in the reign of Nicholas." In the words of De Custine, "the tchinn [the name for this organization] is a nation formed into a regiment ; it is the military system applied to all classes of society, even to those who never go to war." With this universal regimentation in structure went a regimental discipline. The conduct of life was dictated to the citizens at large in the same way as to soldiers. In the reign of Peter and his successors domestic entertainments were appointed and regulated ; the people were compelled to change their costumes ; the clergy to cut off their beards ; and even the harnessing of horses was according to pattern. Occupations were controlled to the extent that "no boyard could enter any profession, or forsake it

when embraced, or retire from public to private life, or dispose of his property, or travel into any foreign country, without the permission of the Czar." This omnipresent rule is well expressed in the close of certain rhymes, for which a military officer was sent to Siberia:

> "Tout se fait par ukase ici;
> C'est par ukase que l'on voyage,
> C'est par ukase que l'on rit."

Taking thus the existing barbarous society of Dahomey, formed of negroes; the extinct semi-civilized empire of the Incas, whose subjects were remote in blood from these; the ancient Egyptian empire peopled by yet other races; the community of the Spartans, again unlike in the type of its men; and the existing Russian nation made up of Slavs and Tartars—we have before us cases in which such similarities of social structure as exist can not be ascribed to inheritance of a common character by the social units. The immense contrasts between the populations of these several societies, too, varying from millions at the one extreme to thousands at the other, negative the supposition that their common structural traits are consequent on size. Nor can it be supposed that likenesses of conditions in respect of climate, surface, soil, flora, fauna, or likenesses of habits caused by such conditions, can have had anything to do with the likenesses of organization in these societies; for their respective habitats present numerous marked unlikenesses. Such traits as they one and all exhibit, not ascribable to any other cause, must thus be ascribed to the habitual militancy characteristic of them all. The results of induction alone would go far to warrant this ascription; and it is fully warranted by their correspondence with the results of deduction, as set forth above.

Any remaining doubts must disappear on observing how continued militancy is followed by further development of the militant organization. Three illustrations will suffice:

When, during Roman conquests, the tendency for the successful general to become despot, repeatedly displayed, finally took effect—when the title *imperator*, military in its primary meaning, became the title for the civil ruler, showing us on a higher platform that genesis of political headship out of military headship visible from the beginning—when, as usually happens, an increasingly-divine character was acquired by the civil ruler, as shown in the assumption of the sacred name Augustus, as well as in the growth of an actual worship of him; there simultaneously became more pronounced those further traits which characterize the militant type in its developed form. Practically, if not nominally, the other powers of the state were absorbed by him. In the words of Duruy, he had—

> the right of proposing, that is, of making, laws; of receiving and trying appeals, i. e., the supreme jurisdiction; of arresting by the tribunitian veto

every measure and every sentence, i. e., of putting his will in opposition to the laws and magistrates; of summoning the senate or the people, and presiding over it, i. e., of directing the electoral assemblages as he thought fit. And these prerogatives he will have not for a single year, but for life; not in Rome only . . . but throughout the empire; not shared with ten colleagues, but exercised by himself alone; lastly, without any account to render, since he never resigns his office.

Along with these changes went an increase in the number and definiteness of social divisions. The Emperor

placed between himself and the masses a multitude of people regularly classed by categories, and piled one above the other in such a way that this hierarchy, pressing with all its weight upon the masses underneath, held the people and factious individuals powerless. What remained of the old patrician nobility had the foremost rank in the city; . . . below it came the senatorial nobility, half hereditary; below that the moneyed nobility, or equestrian order—three aristocracies superposed. . . . The sons of senators formed a class intermediate between the senatorial and the equestrian order. . . . In the second century the senatorial families formed an hereditary nobility with privileges.

At the same time the administrative organization was greatly extended and complicated.

Augustus created a large number of new offices, as the superintendence of public works, roads, aqueducts, the Tiber-bed, distribution of corn to the people. . . . He also created numerous offices of procurators for the financial administration of the empire, and in Rome there were one thousand and sixty municipal officers.

The structural character proper to an army spread in a double way: military officers acquired civil functions and functionaries of a civil kind became partially military. The magistrates appointed by the Emperor, tending to replace those appointed by the people, had, along with their civil authority, military authority; and while "under Augustus the prefects of the pretorium were only military chiefs, . . . they gradually possessed themselves of the whole civil authority, and finally became, after the Emperor, the first personages in the empire." Moreover, the governmental structures grew by incorporating bodies of functionaries who were before independent. "In his ardor to organize everything, he aimed at regimenting the law itself, and made an official magistracy of that which had always been a free profession." To enforce the rule of this extended administration, the army was made permanent, and subjected to severe discipline. With the continued growth of the regulating and coercing organization, the drafts on producers increased; and, as was shown by extracts in a previous chapter concerning the Roman *régime* in Egypt and in Gaul, the working part of the community was reduced more and more to the form of a permanent commissariat. In Italy the condition eventually arrived at was one in which vast tracts were "intrusted to freedmen, whose only consideration was how to cultivate the land with the least

possible expense, and how to extract from their laborers the greatest amount of work with the smallest quantity of food."

An example under our immediate observation may next be taken—that of the German Empire. Such traits of the militant type in Germany as were before manifest have, since the late war, become still more manifest. The army, active and passive, including officers and attached functionaries, has been increased by about one hundred thousand men; and changes in 1875 and 1880, making certain reserves more available, have practically caused a further increase of like amount. Moreover, the smaller German states, having in great part surrendered the administration of their several contingents, the German army has become more consolidated; and even the armies of Saxony, Würtemberg, and Bavaria, being subject to imperial supervision, have in so far ceased to be independent. Instead of each year granting military supplies, as had been the practice in Prussia before the formation of the North-German Confederation, the Parliament of the empire was, in 1871, induced to vote the required annual sum for three years thereafter; in 1874 it did the like for the succeeding seven years; and again in 1880 the greatly increased amount for the augmented army was authorized for the seven years following—steps obviously surrendering popular checks on imperial power. Simultaneously, military officialism has been in two ways replacing civil officialism. Subaltern officers are rewarded for long services by appointments to civil posts—local communes being forced to give them the preference to civilians; and not a few members of the higher civil service, and of the universities, as well as teachers in the public schools, having served as "volunteers of one year," become commissioned officers of the Landwehr. During the stuggles of the so-called Kulturkampf, the ecclesiastical organization became more subordinated by the political. Priests suspended by bishops were maintained in their offices; it was made penal for a clergyman publicly to take part against the government; a recalcitrant bishop had his salary stopped; the curriculum for ecclesiastics was prescribed by the state, and examination by state officials required; church discipline was subjected to state approval; and a power of expelling rebellious clergy from the country was established. Passing to the industrial activities we may note—first, that through sundry steps, from 1873 onward, there has been a progressive transfer of railways into the hands of the state; so that, partly by original construction (mainly of lines for military purposes), and partly by purchase, three fourths of all Prussian railways have been made government property; and the same percentage holds in the other German states: the aim being eventually to make them all imperial. Trade interferences have been extended in various ways—by protectionist tariffs, by revival of the usury laws, by restrictions on Sunday labor. Through its postal service the state has assumed industrial functions—presents acceptances, receives money on

bills of exchange that are due, as also on ordinary bills, which it gets receipted; and, until stopped by shopkeepers' protests, undertook to procure books from publishers. Lastly there come the measures for extending, directly and indirectly, the control over popular life. On the one hand, there are the laws under which, up to the middle of last year, two hundred and twenty-four socialist societies have been closed, one hundred and eighty periodicals suppressed, three hundred and seventeen books, etc., forbidden, and under which sundry places have been reduced to a partial state of siege. On the other hand, may be named Prince Bismarck's scheme for reëstablishing guilds (bodies which by their regulations coerce their members), and his scheme of state insurance, by the help of which the artisan would in a considerable degree have his hands tied. Though these measures have not been carried in the forms proposed, yet the proposal of them sufficiently shows the general tendency. In all which changes we see progress toward a more integrated structure, toward increase of the militant part as compared with the industrial part, toward the replacing of civil organization by military organization, toward the strengthening of restraints over the individual and regulation of his life in greater detail.

The remaining example to be named is that furnished by our own society since the revival of military activity—a revival which has of late been so marked that our illustrated papers are, week after week, occupied with little else than scenes of warfare. Already in the first volume of "The Principles of Sociology," I have pointed out many ways in which the system of compulsory coöperation characterizing the militant type has been trenching on the system of voluntary cooperation characterizing the industrial type; and, since those passages appeared (July, 1876), other changes in the same direction have taken place. Within the military organization itself, we may note the increasing assimilation of the volunteer forces to the regular army, now going to the extent of a movement for making them available abroad, so that, instead of defensive action for which they were created, they can be used for offensive action; and we may also note that the tendency shown in the army during a past generation to sink the military character whenever possible, by putting on civilian dresses, is now checked by an order to officers in garrison towns to wear their uniforms when off duty, as they do in more militant countries. Whether, since the date named, usurpations of civil functions by military men (which had in 1873–'74 gone to the extent that there were ninety-seven colonels, majors, captains, and lieutenants employed from time to time as inspectors of science and art classes) have gone further I can not say; but there has been a manifest extension of the military spirit and discipline among the police, with the effect that, wearing helmet-shaped hats, beginning to carry revolvers, and looking on themselves as half soldiers, they have come to speak of the people as "civil-

ians," and in some cases exercise over "civilians" an inspection of a military kind; as instance the chief of the Birmingham police, Major Bond, whose subalterns track home men who are unsteady from drink but quiet, and prosecute them next morning; or as instance the regulation by policemen's commands of the conflicting streams of vehicles in the London streets. To an increasing extent the executive has been overriding the other governmental agencies; as in the Cyprus business, and as in the doings of the Indian Viceroy under secret instructions from home. In various minor ways are shown endeavors to free officialism from popular checks; as in the desire expressed in the House of Lords that the hanging of convicts in prisons, intrusted entirely to the authorities, should have no other witnesses; and as in the advice given by the late Home Secretary (on May 11, 1878) to the Derby town council, that it should not interfere with the chief constable (a military man) in his government of the force under him—a step toward centralizing local police control in the home office. Simultaneously we see various actual or prospective extensions of public agency, replacing or restraining private agency. There is the "endowment of research," which, already partially carried out by a government fund, many wish to carry further; there is the proposed act for establishing a registration of authorized teachers; there is the bill which provides central inspection for local public libraries; there is the scheme for compulsory insurance—a scheme showing us in an instructive manner the way in which the regulating policy extends itself: compulsory charity having generated improvidence, there comes compulsory insurance as a remedy for the improvidence. Other proclivities toward institutions belonging to the militant type are seen in the increasing demand for some form of protection, and in the lamentations uttered by the "society papers" that dueling has gone out. Nay, even through the party which by position and function is antagonistic to militancy, we see that militant discipline is spreading; for the caucus-system, established for the better organization of liberalism, is one which necessarily, in a greater or less degree, centralizes authority and controls individual action.

Besides seeing, then, that the traits to be inferred *a priori* as characterizing the militant type constantly exist in societies which are permanently militant in high degrees, we also see that in other societies increase of militant activity is followed by development of such traits.

In some places I have stated, and in other places implied, that a necessary relation exists between the structure of a society and the natures of its citizens. Here it will be well to observe in detail the characters proper to, and habitually exemplified by, the members of a typically militant society.

Other things equal, a society will be successful in war in propor-

tion as its members are endowed with bodily vigor and courage. And, on the average, among conflicting societies there will be a survival and spread of those in which the physical and mental powers called for in battle are not only most marked but also most honored. Egyptian and Assyrian sculptures and inscriptions show us that prowess was the thing above all others thought most worthy of record. Of the words good, just, etc., as used by the ancient Greeks, Grote remarks that they "signify the man of birth, wealth, influence, and daring, whose arm is strong to destroy or to protect, whatever may be the turn of his moral sentiments; while the opposite epithet, bad, designates the poor, lowly, and weak, from whose dispositions, be they ever so virtuous, society has little to hope or to fear." In the identification of virtue with bravery among the Romans, we have a like implication. During early turbulent times throughout Europe, the knightly character, which was the honorable character, primarily included fearlessness: lacking this, good qualities were of no account; but, with this, sins of many kinds were condoned.

If, among antagonist groups of primitive men, some tolerated more than others the killing of their members—if, while some always retaliated, others did not—those which did not retaliate, continually aggressed on with impunity, would either gradually disappear or have to take refuge in undesirable habitats. Hence there is a survival of the unforgiving. Further, the *lex talionis*, primarily arising between antagonist groups, becomes the law within the group; and chronic feuds between component families and clans everywhere proceed upon the general principle of life for life. Under the militant *régime* revenge becomes a virtue, and failure to revenge a disgrace. Among the Feejeeans, who foster anger in their children, it is not infrequent for a man to commit suicide rather than live under an insult—rather than submit to an unavenged injury; and in other cases the dying Feejeean bequeaths the duty of inflicting vengeance to his children. This sentiment and resulting practices we trace among peoples otherwise wholly alien, who are, or have been, actively militant. In the remote East may be instanced the Japanese. They are taught that "with the slayer of his father a man may not live under the same heaven; against the slayer of his brother a man must never have to go home to fetch a weapon; with the slayer of his friend a man may not live in the same state." And in the West may be instanced France during feudal days, when the relations of one killed or injured were required by custom to retaliate on any relations of the offender—even those living at a distance, and knowing nothing of the matter. Down even to the time of the Abbé Brantôme the spirit was such that that ecclesiastic, bequeathing to his nephews the duty of avenging any unredressed wrongs done to him in his old age, says of himself: "I may boast, and I thank God for it, that I never received an injury without being revenged on the author of it." That, where militancy is active,

revenge, private as well as public, becomes a duty, is well shown at the present time among the Montenegrins—a people who have been at war with the Turks for centuries. "Dans le Montenegro," says Boué, "on dira d'un homme d'une natrie [clan] ayant tué un individu d'une autre: Cette natrie nous doit une tête, et il faut que cette dette soit acquitté, car qui ne se venge pas ne ce sancitie pas."

Where activity in destroying enemies is chronic, destruction will become a source of pleasure; where success in subduing fellow-men is above all things honored, there will arise delight in the forcible exercise of mastery; and, with pride in spoiling the vanquished, will go disregard for the rights of property at large. As it is incredible that men should be courageous in face of foes and cowardly in face of friends, so it is incredible that the other feelings fostered by perpetual conflicts abroad should not come into play at home. We have just seen that, with the pursuit of vengeance outside the society, there goes the pursuit of vengeance inside the society; and whatever other habits of thought and action constant war necessitates must show their effects in the social life at large. Facts from various places and times prove that in militant societies the claims of life, liberty, and property are little regarded. The Dahomans, warlike to the extent that both sexes are warriors, and by whom slave-hunting invasions are, or were, annually undertaken "to furnish funds for the royal exchequer," show their blood-thirstiness by their annual "customs," at which multitudinous victims are publicly slaughtered for the popular gratification. The Feejeeans, again, highly militant in their activities and type of organization, who display their recklessness of life not only by killing their own people for cannibal feasts, but by destroying immense numbers of their infants and by sacrificing victims on trivial occasions, such as launching a new canoe, so much applaud ferocity that to commit a murder is a glory. Early records of Asiatics and Europeans show us the like relation. What accounts there are of the primitive Mongols, who, when united, massacred Western peoples wholesale, show us a chronic reign of violence, both within and without their tribes; while domestic assassinations, which from the beginning have characterized the militant Turks, continue to characterize them down to our own day! In proof that it was so with the Greek and Latin races, it suffices to instance the slaughter of the two thousand Helots by the Spartans, whose brutality was habitual, and the murder of large numbers of suspected citizens by jealous Roman emperors, who also, like their subjects, manifested their love of bloodshed in their arenas. That where life is little regarded there can be but little regard for liberty, follows necessarily: those who do not hesitate to end another's activities by killing him will still less hesitate to restrain his activities by holding him in bondage. Militant savages, whose captives, when not eaten, are enslaved, habitually show us this absence of regard for fellow-men's freedom, which characterizes the members

of militant societies in general. How little, under the militant *régime*, more or less markedly displayed in all early historic societies, there was any sentiment against depriving men of their liberties, is sufficiently shown by the fact that even in the teachings of primitive Christianity there was no express condemnation of slavery. Naturally the like holds with the right of property. Where mastery established by force is honorable, claims to possession by the weaker are likely to be little respected by the stronger. In Feejee it is considered chief-like to seize a subject's goods; and theft is virtuous if undiscovered. In Dahomey the king "squeezes" any one as soon as he acquires property. Among the Spartans "the ingenious and successful pilferer gained applause with his booty." In mediæval Europe with perpetual robberies of one society by another there went perpetual robberies within each society. Under the Merovingians "the murders and crimes it ["The Ecclesiastical History of the Franks"] relates have almost all for their object the possession of the treasure of the murdered persons"; and under Charlemagne plunder by officials was chronic: the moment his back was turned "the provosts of the king appropriated the funds intended to furnish food and clothing for the artisans."

Where warfare is habitual, and the required qualities most needful and therefore most honored, those whose lives do not display them are treated with contempt, and their occupations regarded as dishonorable. In early stages labor is the business of women and of slaves—conquered men and the descendants of conquered men; and trade of every kind, carried on by subject classes, long continues to be identified with lowness of origin and nature. In Dahomey, "agriculture is despised because slaves are employed in it." "The Japanese nobles and placemen, even of secondary rank, entertain a sovereign contempt for traffic." Of the ancient Egyptians Wilkinson says, "Their prejudices against mechanical employments, as far as regarded the soldier, were equally strong as in the rigid Sparta." "For trade and commerce the (ancient) Persians were wont to express extreme contempt," writes Rawlinson. The progress of class differentiation which accompanied the conquering wars of the Romans, was furthered by establishment of the rule that it was disgraceful to take money for work, and also by the law forbidding senators and senators' sons from engaging in speculation. And how great has been the scorn expressed by the militant classes for the trading classes throughout Europe down to quite recent times, needs no showing.

That there may be willingness to risk life for the benefit of the society, there must be much of the feeling called patriotism. Though the belief that it is glorious to die for one's country can not be regarded as essential, since mercenaries fight without it, yet it is obvious that such a belief must conduce greatly to success in war; and that entire absence of it must be so unfavorable to offensive and de-

fensive action that failure and subjugation, will, other things equal, be likely to result. Hence the sentiment of patriotism will be established by the survival of societies the members of which are most characterized by it.

With this there needs to be united the instinct of obedience. The possibility of that united action by which, other things equal, war is made successful, depends on the readiness of individuals to subordinate their wills to the will of a commander or ruler. Loyalty is essential. In early stages the manifestation of it is but temporary, as among the Araucanians, who, ordinarily showing themselves "repugnant to all subordination, are then (when war is impending) prompt to obey, and submissive to the will of their military sovereign" appointed for the occasion. And with development of the militant type this sentiment becomes permanent. Thus, Erskine tells us that the Feejeeans are intensely loyal: men buried alive in the foundations of a king's house considered themseves honored by being so sacrificed; and the people of a slave district "said it was their duty to become food and sacrifice for the chiefs." So in Dahomey there is felt for the king "a mixture of love and fear, little short of adoration." In ancient Egypt, again, where "blind obedience was the oil which caused the harmonious working of the machinery" of social life, the monuments on every side show with wearisome iteration the daily acts of subordination—of slaves and others to the dead man, of captives to the king, of the king to the gods. Though, for reasons already pointed out, chronic war did not generate in Sparta a supreme political head, to whom there could be shown implicit obedience, yet the obedience shown to the political agency which grew up was profound: individual wills were in all things subordinate to the public will expressed by the established authorities. In primitive Rome, too, in the absence of a divinely-descended king to whom submission could be shown, there was submission to an appointed king, qualified only by expressions of opinion on special occasions; and the principle of absolute obedience, slightly mitigated in the relations of the community as a whole to its ruling agency, was unmitigated within its component groups. And that throughout European history, alike on small and on large scales, we see the sentiment of loyalty dominant where the militant type of structure is pronounced, is a truth that will be admitted without detailed proof.

From these conspicuous traits of nature let us turn to certain consequent traits which are less conspicuous, and which have results of less manifest kinds. Along with loyalty naturally goes faith—the two being, indeed, scarcely separable. Readiness to obey the commander in war implies belief in his military abilities; and readiness to obey him during peace implies belief that his abilities extend to civil affairs also. Imposing on men's imaginations, each new conquest augments his authority. There come more frequent and more decided

evidences of his regulative action over men's lives ; and these generate the idea that his power is boundless. Unlimited faith in governmental agency is fostered. Generations brought up under a system which controls all affairs, private and public, tacitly assume that affairs can only thus be controlled. Those who have experience of no other *régime* become unable to imagine any other *régime*. In such societies as that of ancient Peru, for example, where, as we have seen, regimental rule was universal, there were no materials for framing the thought of an industrial life spontaneously carried on and spontaneously regulated.

By implication, there result repression of individual initiative and a consequent lack of private enterprise. In proportion as an army becomes organized it is reduced to a state in which the independent action of its members is forbidden. And, in proportion as regimentation pervades the society at large, each member of it, directed or restrained at every turn, has little or no power of conducting his business otherwise than by established routine. Slaves can do only what they are told by their masters ; their masters can not do anything that is unusual without official permission ; and no permission is to be obtained from the local authority until superior authorities through their ascending grades have been consulted. Hence the mental state generated is that of passive acceptance and expectancy. Where the militant type is fully developed, everything must be done by public agencies ; not only for the reason that these occupy all spheres, but for the further reason that, did they not occupy them, there would arise no other agencies—the prompting ideas and sentiments having been obliterated.

There must be added a concomitant influence on the intellectual nature which coöperates with the moral influences just named. Personal causation is alone recognized, and the conception of impersonal causation is prevented from developing. The primitive man has no idea of cause in the modern sense. The only agents included in his theory of things are living persons and the ghosts of dead persons. All unusual occurrences, together with those usual ones liable to variation, he ascribes to supernatural beings. And this system of interpretration survives through early stages of civilization ; as we see, for example, among the Homeric Greeks, by whom wounds, deaths, and escapes in battle, were ascribed to the enmity or the aid of the gods, and by whom good and bad acts were held to be divinely prompted. Continuance and development of militant forms and activities maintain this way of thinking. In the first place it indirectly hinders the discovery of causal relations. The sciences grow out of the arts—begin as generalizations of truths which practice of the arts makes manifest. In proportion as processes of production multiply in their kinds and increase in their complexities, more numerous uniformities come to be recognized ; and the ideas of necessary relation and physi-

cal cause arise and develop. Consequently, by discouraging industrial progress, militancy checks the replacing of ideas of personal agency by ideas of impersonal agency. In the second place, it does the like by direct repression of intellectual culture. Naturally a life occupied in acquiring knowledge, like a life occupied in industry, is regarded with contempt by a people devoted to war. The Spartans clearly exemplified this relation in ancient times; and it was again exemplified during feudal ages in Europe, when learning was scorned as proper only for clerks and the children of mean people. And obviously, in proportion as warlike activities are antagonistic to the advance of science, they further retard that emancipation from primitive ideas which ends in recognition of natural uniformities. In the third place, and chiefly, the effect in question is produced by the conspicuous and perpetual experience of personal agency which the militant *régime* yields. In the army, from the commander-in-chief down to the private undergoing drill, every movement is directed by a superior; and, throughout the society, in proportion as its regimentation is elaborate, things are hourly seen to go thus or thus, according to the regulating wills of the ruler and his subordinates. In the interpretation of social affairs, personal causation is consequently alone recognized. History comes to be made up of the doings of remarkable men; and it is tacitly assumed that societies have been formed by them. Wholly foreign to the habit of mind as is the thought of impersonal causation, the course of social evolution is unperceived. The natural genesis of social structures and functions is an utterly alien conception, and appears absurd when alleged. The notion of a self-regulating social process is unintelligible. So that militancy molds the citizen into a form not only morally adapted, but intellectually adapted—a form which can not think away from the entailed system.

In three ways, then, we are shown the character of the militant type of political organization. Observe the congruities which comparison of results discloses.

Certain conditions, manifest *a priori*, have to be fulfilled by a society fitted for preserving itself in presence of antagonist societies. To be in the highest degree efficient, the corporate action needed for preserving the corporate life must be joined in by every one. Other things equal, the fighting power will be greatest where those who can not fight labor exclusively to support and help those who can: an evident implication being that the working part shall be no larger than is required for these ends. The efforts of all being utilized directly or indirectly for war, will be most effectual when they are most combined; and, besides union among the combatants, there must be such union of the non-combatants with them as renders the aid of these fully and promptly available. To satisfy these requirements, the life, the actions, and the possessions of each individual must be

held at the service of the society. This universal service, this combination, and this merging of individual claims, presuppose a despotic controlling agency. That the will of the soldier-chief may be operative when the aggregate is large, there must be sub-centers and sub-sub-centers in descending grades, through whom orders may be conveyed and enforced, both throughout the combatant part and the non-combatant part. As the commander tells the soldier both what he shall not do and what he shall do, so, throughout the militant community at large, the rule is both negatively regulative and positively regulative: it not only restrains, but it directs: the citizen as well as the soldier lives under a system of compulsory coöperation. Development of the militant type involves increasing rigidity, since the cohesion, the combination, the subordination, and the regulation, to which the units of a society are subjected by it, inevitably decrease their ability to change their social positions, their occupations, their localities.

On inspecting sundry societies, past and present, large and small, which are, or have been, characterized in high degrees by militancy, we are shown, *a posteriori*, that amid the differences due to race, to circumstances, and to degrees of development, there are fundamental similarities of the kinds above inferred *a priori*. Modern Dahomey and Russia, as well as ancient Peru, Egypt, and Sparta, exemplify that owning of the individual by the state in life, liberty, and goods, which is proper to a social system adapted for war. And, that, with changes further fitting a society for warlike activities, there spread throughout it an officialism, a dictation, and a superintendence, akin to those under which the soldiery lives, we are shown by imperial Rome, by imperial Germany, and by England since its late aggressive activities.

Lastly comes the evidence furnished by the adapted characters of the men who compose militant societies. Making success in war the highest glory, they are led to identify goodness with bravery and strength. Revenge becomes a sacred duty with them; and, acting at home on the law of retaliation which they act on abroad, they similarly at home as abroad are ready to sacrifice others to self: their sympathies, continually deadened in war, can not be active during peace. They must have a patriotism which regards the triumph of their society as the supreme end of the action; they must possess the loyalty whence flows obedience to authority; and that they may be obedient they must have abundant faith. With faith in authority and consequent readiness to be directed, naturally goes relatively little power of initiation. The habit of seeing everything officially controlled fosters the belief that official control is everywhere needful; and a course of life which makes personal causation familiar and negatives experience of impersonal causation produces an inability to conceive of any social processes as carried on under self-regulating arrange-

ments. And these traits of individual nature, needful concomitants as we see of the militant type, are those which we observe in the members of actual militant societies.

THE CULTIVATION OF MEDICAL SCIENCE.

OPENING ADDRESS BEFORE THE INTERNATIONAL MEDICAL CONGRESS.

By the President, Sir JAMES PAGET.

AS I look around this hall my admiration is moved not only by the number and total power of the minds which are here, but by their diversity, a diversity in which I believe they fairly represent the whole of those who are engaged in the cultivation of our science. For here are minds representing the distinctive characters of all the most gifted and most educated nations: characters still distinctly national, in spite of the constantly increasing intercourse of the nations. And from many of these nations we have both elder and younger men; thoughtful men and practical; men of fact and men of imagination; some confident, some skeptic; various, also, in education, in purpose and mode of study, in disposition, and in power. And scarcely less various are the places and all the circumstances in which those who are here have collected and have been using their knowledge. For I think that our calling is preëminent in its range of opportunities for scientific study. It is not only that the pure science of human life may match with the largest of the natural sciences in the complexity of its subject-matter; not only that the living human body is, in both its material and its indwelling forces, the most complex thing yet known, but that in our practical duties this most complex thing is presented to us in an almost infinite multiformity. For in practice we are occupied, not with a type and pattern of the human nature, but with all its varieties in all classes of men, of every age and every occupation, and all climates and all social states; we have to study men singly and in multitudes, in poverty and in wealth, in wise and unwise living, in health and all the varieties of disease; and we have to learn, or at least try to learn, the results of all these conditions of life, while in successive generations and in the mingling of families they are heaped together, confused, and always changing. In every one of all these conditions, man, in mind and body, must be studied by us; and every one of them offers some different problems for inquiry and solution. Wherever our duty or our scientific curiosity, or, in happy combination, both, may lead us, there are the materials and there the opportunities for separate original research.

Now, from these various opportunities of study, men are here in

Congress. Surely, whatever a multitude and diversity of minds can in a few days do for the promotion of knowledge, may be done here.

But it is not proposed to leave the work of the Congress to what would seem like chances and disorder, good as the result might be; nor yet to the personal influences by which we may all be made fitter for work, though these may be very potent. In the stir and controversy of meetings such as we shall have, there can not fail to be useful emulation; by the examples that will appear of success in research, many will be moved to more enthusiasm, many to more keen study of the truth; our range of work will be made wider, and we shall gain that greater interest in each other's views and that clearer apprehension of them which are always attained by personal acquaintance and by memories of association in pleasure as well as in work. But as it will not be left to chance, so neither will sentiment have to fulfill the chief duties of the Congress.

Following the good example of our predecessors, certain subjects have been selected which will be chiefly though not exclusively discussed, and the discussions are to be in the sections into which we shall soon divide.

Of these subjects it would not be for me to speak even if I were competent to do so; unless I may say that they are so numerous and complete that—together with the opening addresses of the presidents of sections—they leave me nothing but such generalities as may seem commonplace. They have been selected, after the custom of former meetings, from the most stirring and practical questions of the day; they are those which must occupy men's minds, and on which there is at this time most reason to expect progress, or even a just decision, from very wide discussion. They will be discussed by those most learned in them, and in many instances by those who have spent months or years in studying them, and who now offer their work for criticism and judgment.

I will only observe that the subjects selected in every section involve questions in the solution of which all the varieties of mind and knowledge of which I have spoken may find their use. For there are questions, not only on many subjects, but in all stages of progress toward settlement. In some the chief need seems to be the collection of facts well observed by many persons. I say by many, not only because many facts are wanted, but because in all difficult research it is well that each apparent fact should be observed by many; for things are not what they appear to each one mind. In that which each man believes that he observes, there is something of himself; and for certainty, even on matters of fact, we often need the agreement of many minds, that the personal element of each may be counteracted. And much more is this necessary in the consideration of the many questions which are to be decided by discussing the several values of admitted facts and of probabilities, and of the conclusions drawn from them.

For, on questions such as these, minds of all kinds may be well employed. Here there will be occasion even for those which are not unconditionally praiseworthy, such as those that habitually doubt, and those to whom the invention of arguments is more pleasing than the mere search for truth. Nay, we may be able to observe the utility even of error. We may not, indeed, wish for a prevalence of errors; they are not more desirable than are the crime and misery which evoke charity. And yet in a congress we may palliate them, for we may see how, as we may often read in history, errors, like doubts and contrary pleadings, serve to bring out the truth, to make it express itself in clearest terms and show its whole strength and value. Adversity is an excellent school for truth as well as for virtue.

But that which I would chiefly note, in relation to the great variety of minds which are here, is that it is characteristic of that mental pliancy and readiness for variation which is essential to all scientific progress, and which a great international congress may illustrate and promote. In all the subjects for discussion we look for the attainment of some novelty and change in knowledge or belief; and after every such change there must ensue a change in some of the conditions of thinking and of working. Now, for all these changes minds need to be pliant and quick to adjust themselves. For all progressive science there must be minds that are young, whatever may be their age.

Just as the discovery of auscultation brought to us the necessity for a refined cultivation of the sense of hearing, which was before of only the same use in medicine as in the common business of life; or, as the employment of the numerical method in estimating the value of facts required that minds should be able to record and think in ways previously unused; or, as the acceptance of the doctrine of evolution has changed the course of thinking in whole departments of science—so is it, in less measure, in every less advance of knowledge. All such advances change the circumstances of the mental life, and minds that can not or will not adjust themselves become less useful, or must at least modify their manner of utility. They may continue to be the best defenders of what is true; they may strengthen and expand the truth, and may apply it in practice with all the advantages of experience; they may thus secure the possessions of science and use them well; but they will not increase them.

It is with minds as with living bodies. One of their chief powers is in their self-adjustment to the varying conditions in which they have to live. Generally those species are the strongest and most abiding that can thrive in the widest range of climate and of food. And of all the races of men they are the mightiest and most noble who are, or by self-adjustment can become, most fit for all the new conditions of existence in which by various changes they may be placed. These are they who prosper in great changes of their social state; who, in successive generations, grow stronger by the production of a population

so various that some are fitted to each of all the conditions of material and mode of life which they can discover or invent. These are most prosperous in the highest civilization; these whom nature adapts to the products of their own arts.

Or, among other groups, the mightiest are those who are strong alike on land and sea; who can explore and colonize, and in every climate can replenish the earth and subdue it; and this not by tenacity or mere robustness, but rather by pliancy and the production of varieties fit to abide and increase in all the various conditions of the world around.

Now, it is by no distant analogy that we trace the likeness between these in their successful contests with the material conditions of life and those who are to succeed in the intellectual strife with the difficulties of science and of art. There must be minds which in variety may match with all the varieties of the subject-matters and minds which, at once or in swift succession, can be adjusted to all the increasing and changing modes of thought and work.

Such are the minds we need; or, rather, such are the minds we have; and these in great meetings prove and augment their worth. Happily the natural increase in the variety of minds in all cultivated races is—whether as cause or as consequence—nearly proportionate to the increasing variety of knowledge. And it has become proverbial, and is nearly true in science and art, as it is in commerce and in national life, that, whatever work is to be done, men are found or soon produced who are exactly fit to do it.

But it need not be denied that, in the possession of this first and chiefest power for the increase of knowledge, there is a source of weakness. In works done by dissimilar and independent minds, dispersed in different fields of study, or only gathered into self-assorted groups, there are apt to be discord and great waste of power. There is, therefore, need that the workers should from time to time be brought to some consent and unity of purpose; that they should have opportunity for conference and mutual criticism, for mutual help and the tests of free discussion. This it is which, on the largest scale and most effectually, our Congress may achieve; not indeed by striving after a useless and happily impossible uniformity of mind or method, but by diminishing the lesser evil of waste and discord which is attached to the far greater good of diversity and independence. Now, as in numbers and variety the Congress may represent the whole multitude of workers everywhere dispersed, so in its gathering and concord it may represent a common consent that, though we may be far apart and different, yet our work is and shall be essentially one; in all its parts mutually dependent, mutually helpful, in no part complete or self-sufficient. We may thus declare that as we who are many are met to be members of one body, so our work for science shall be one, though manifold; that as we, who are of many nations, will for a time forget

our nationalities, and will even repress our patriotism, unless for the promotion of a friendly rivalry, so will we in our work, whether here and now or everywhere and always, have one end and one design—the promotion of the whole science and whole art of healing.

It may seem to be a denial of this declaration of unity that, after this general meeting, we shall separate into sections more numerous than in any former Congress. Let me speak of these sections to defend them; for some maintain that, even in such a division of studies as these may encourage, there is a mischievous dispersion of forces. The science of medicine, which used to be praised as one and indivisible, is broken up, they say, among specialists, who work in conflict rather than in concert, and with mutual distrust more than mutual help.

But let it be observed that the sections which we have instituted are only some of those which are already recognized in many countries, in separate societies, each of which has its own place and rules of self-government and its own literature. And the division has taken place naturally in the course of events which could not be hindered. For the partial separation of medicine, first from the other natural sciences, and now into sections of its own, has been due to the increase of knowledge being far greater than the increase of individual mental power.

I do not doubt that the average mental power constantly increases in the successive generations of all well-trained peoples; but it does not increase so fast as knowledge does, and thus in every science, as well as in our own, a small portion of the whole sum of knowledge has become as much as even a large mind can hold and duly cultivate. Many of us must, for practical life, have a fair acquaintance with many parts of our science, but none can hold it all; and for complete knowledge, or for research, or for safely thinking out beyond what is known, no one can hope for success unless by limiting himself within the few divisions of the science for which, by nature or by education, he is best fitted. Thus, our division into sections is only an instance of that division of labor which, in every prosperous nation, we see in every field of active life, and which is always justified by more work better done.

Moreover, it can not be said that in any of our sections there is not enough for a full, strong mind to do. If any one will doubt this, let him try his own strength in the discussions of several of them.

In truth, the fault of specialism is not in narrowness, but in the shallowness and the belief in self-sufficiency with which it is apt to be associated. If the field of any specialty in science be narrow, it can be dug deeply. In science, as in mining, a very narrow shaft, if only it be carried deep enough, may reach the richest stores of wealth and find use for all the appliances of scientific art. Not in medicine alone, but in every department of knowledge, some of the grandest results of research and of learning, broad and deep, are to be found

in monographs on subjects that, to the common mind, seemed small and trivial.

And study in a Congress such as this may be a useful remedy for self-sufficiency. Here every group may find a rare occasion, not only for an opportune assertion of the supreme excellence of its own range and mode of study, but for the observation of the work of every other. Each section may show that its own facts must be deemed sure, and that by them every suggestion from without must be tested; but each may learn to doubt every inference of its own which is not consistent with the facts or reasonable beliefs of others; each may observe how much there is in the knowledge of others which should be mingled with its own; and the sum of all may be the wholesome conviction of all, that we can not justly estimate the value of a doctrine in one part of our science till it has been tried in many or in all.

We were taught this in our schools; and many of us have taught that all the parts of medical science are necessary to the education of the complete practitioner. In the independence of later life some of us seem too ready to believe that the parts we severally choose may be self-sufficient, and that what others are learning can not much concern us. A fair study of the whole work of the Congress may convince us of the fallacy of this belief. We may see that the test of truth in every part must be in the patient and impartial trial of its adjustment with what is true in every other. All perfect organizations bear this test; all parts of the whole body of scientific truth should be tried by it.

Moreover, I would not, from a scientific point of view, admit any estimate of the comparative importance of the several divisions of our science, however widely they may differ in their present utilities. And this I would think right, not only because my office as president binds me to a strict impartiality and to the claim of freedom of research for all, but because we are very imperfect judges of the whole value of any knowledge, or even of single facts. For every fact in science, wherever gathered, has not only a present value, which we may be able to estimate, but a living and germinal power of which none can guess the issue.

It would be difficult to think of anything that seemed less likely to acquire practical utility than those researches of the few naturalists who, from Leeuwenhoek to Ehrenberg, studied the most minute of living things, the *Vibrionidæ*. Men boasting themselves as practical might ask, "What good can come of it?" Time and scientific industry have answered: "This good—those researches have given a more true form to one of the most important practical doctrines of organic chemistry; they have introduced a great beneficial change in the most practical part of surgery; they are leading to one as great in the practice of medicine; they concern the highest interests of agriculture, and their power is not yet exhausted."

And as practical men were, in this instance, incompetent judges of the value of scientific facts, so were men of science at fault when they missed the discovery of anæsthetics. Year after year the influences of laughing-gas and of ether were shown: the one fell to the level of the wonders displayed by itinerant lecturers, students made fun with the other; they were the merest practical men, men looking for nothing but what might be straightway useful, who made the great discovery which has borne fruit not only in the mitigation of suffering, but in a wide range of physiological science.

The history of science has many similar facts, and they may teach that any man will be both wise and dutiful if he will patiently and thoughtfully do the best he can in the field of work in which, whether by choice or chance, his lot is cast. There let him, at least, search for truth, reflect on it, and record it accurately; let him imitate that accuracy and completeness of which I think we may boast that we have, in the descriptions of the human body, the highest instance yet attained in any branch of knowledge. Truth so recorded can not remain barren.

In thus speaking of the value of careful observation and records of facts, I seem to be in agreement with the officers of all the sections; for, without any intended consent, they have all proposed such subjects for discussion as can be decided only by well-directed facts and fair direct inductions from them. There are no questions on theories or mere doctrines. This, I am sure, may be ascribed, not to any disregard of the value of good reasoning or of reasonable hypotheses, but partly to the just belief that such things are ill-suited for discussion in large meetings, and partly to the fact that we have no great opponent schools, no great parties named after leaders or leading doctrines about which we are in the habit of disputing. In every section the discussions are to be on definite questions, which, even if they be associated with theory or general doctrines, may yet be soon brought to the test of fact; there is to be no use of doctrinal touchstones.

I am speaking of no science but our own. I do not doubt that in others there is advantage in dogma, or in the guidance of a central organizing power, or in divisions and conflicting parties. But in the medical sciences I believe that the existence of parties founded on dominant theories has always been injurious; a sign of satisfaction with plausible errors, or with knowledge which was even for the time imperfect. Such parties used to exist, and the personal histories of their leaders are some of the most attractive parts of the history of medicine: but, although in some instances an enthusiasm for the master-mind may have stirred a few men to unusual industry, yet very soon the disciples seem to have been fascinated by the distinctive doctrine, content to bear its name, and to cease from active scientific work. The dominance of doctrine has promoted the habit of inference, and repressed that of careful observation and induction. It has encouraged

that fallacy to which we are all too prone, that we have at length reached an elevated sure position on which we may rest, and only think and guide. In this way specialism in doctrine or in method of study has hindered the progress of science more than the specialism which has attached itself to the study of one organ or of one method of practice. This kind of specialism may enslave inferior minds: the specialism of doctrine can enchant into mere dreaming those that should be strong and alert in the work of free research.

I speak the more earnestly of this because it may be said, if our Congress be representative, as it surely is, may we not legislate? May we not declare some general doctrines which may be used as tests and as guides for future study? We had better not.

The best work of our International Congress is in the clearing and strengthening of the knowledge of realities; in bringing, year after year, all its force of numbers and varieties of minds to press forward the demonstration and diffusion of truth as nearly to completion as may from year to year be possible. Thus, chiefly, our Congress may maintain and invigorate the life of our science. And the progress of science must be as that of life. It sounds well to speak of the temple of science, and of building and crowning the edifice. But the body of science is not as any dead thing of human work, however beautiful; it is as something living, capable of development and a better growth in every part. For, as in all life the attainment of the highest condition is only possible through the timely passing-by of the less good, that it may be replaced by the better, so is it in science. As time passes, that which seemed true and was very good becomes relatively imperfect truth, and the truth more nearly perfect takes its place.

We may read the history of the progress of truth in science as a paleontology. Many things which, as we look far back, appear, like errors, monstrous and uncouth creatures, were, in their time, good and useful, as good as possible. They were the lower and less perfect forms of truth which, amid the floods and stifling atmospheres of error, still survived; and just as each successive condition of the organic world was necessary to the evolution of the next following higher state, so from these were slowly evolved the better forms of truth which we now hold.

This thought of the likeness between the progress of scientific truth and the history of organic life may give us all the better courage in a work which we can not hope to complete, and in which we see continual and sometimes disheartening change. It is, at least, full of comfort to those of us who are growing old. We that can read in memory the history of half a century might look back with shame and deep regret at the imperfections of our early knowledge if we might not be sure that we held, and sometimes helped onward, the best things that were, in their time, possible, and that they were necessary steps to the better present, even as the present is to the still better future.

Yes—to the far better future; for there is no course of Nature more certain than is the upward progress of science. We may seem to move in circles, but they are the circles of a constantly ascending spiral; we may seem to sway from side to side, but it is only as on a steep ascent which must be climbed in zigzag.

What may be the knowledge of the future none can guess. If we could conceive a limit to the total sum of mental power which will be possessed by future multitudes of well-instructed men, yet could we not conceive a limit to the discovery of the properties of materials which they will bend to their service. We may find the limit of the power of our unaided limbs and senses; but we can not guess at a limit to the means by which they may be assisted, or to the invention of instruments which will become only a little more separate from our mental selves than are the outer sense-organs with which we are constructed.

In the certainty of this progress the great question for us is, what shall we contribute to it? It will not be easy to match the recent past. The advance of medical knowledge within one's memory is amazing, whether reckoned in the wonders of the science not yet applied, or in practical results in the general lengthening of life, or, which is still better, in the prevention and decrease of pain and misery, and in the increase of working power. I can not count or recount all that in this time has been done; and I suppose there are very few, if any, who can justly tell whether the progress of medicine has been equal to that of any other great branch of knowledge during the same time. I believe it has been; I know that the same rate of progress can not be maintained without the constant and wise work of thousands of good intellects; and the mere maintenance of the same rate is not enough, for the rate of the progress of science should constantly increase. That in the last fifty years was at least twice as great as that in the previous fifty. What will it be in the next, or, for a more useful question, what shall we contribute to it?

I have no right to prescribe for more than this week. In this let us do heartily the proper work of the Congress, teaching, learning, discussing, looking for new lines for research, planning for mutual help, forming new friendships. It will be hard work if we will do it well; but we have not met for mere amusement or for recreation, though for that I hope you will find fair provision, and enjoy it the better for the work preceding it.

And when we part let us bear away with us, not only much more knowledge than we came with, but some of the lessons for our conduct in the future which we may learn in reflecting the work of our Congress.

In the number and intensity of the questions brought before us, we may see something of our responsibility. If we could gather into thought the amounts of misery or happiness, of helplessness or of

power for work, which may depend on the answers to all the questions that will come before us, this might be a measure of our responsibility. But we can not count it; let us imagine it; we can not even in imagination exaggerate it. Let us bear it always in our mind, and remind ourselves that our responsibility will constantly increase. For, as men become in the best sense better educated, and the influence of scientific knowledge on their moral and social state increases, so among all sciences there is none of which the influence, and therefore the responsibility, will increase more than ours, because none more intimately concerns man's happiness and working power.

But, more clearly in the recollections of the Congress, we may be reminded that in our science there may be, or, rather, there really is, a complete community of interest among men of all nations. On all the questions before us we can differ, discuss, dispute, and stand in earnest rivalry; but all consistently with friendship, all with readiness to wait patiently till more knowledge shall decide which is in the right. Let us resolutely hold to this when we are apart: let our internationality be a clear abiding sentiment, to be, as now, declared and celebrated at appointed times, but never to be forgotten; we may, perhaps, help to gain a new honor for science, if we thus suggest that in many more things, if they were as deeply and dispassionately studied, there might be found the same complete identity of international interests as in ours.

And then, let us always remind ourselves of the nobility of our calling. I dare to claim for it that, among all the sciences, ours, in the pursuit and use of truth, offers the most complete and constant union of those three qualities which have the greatest charm for pure and active minds—novelty, utility, and charity. These three, which are sometimes in so lamentable disunion, as in the attractions of novelty without either utility or charity, are in our researches so combined that, unless by force or willful wrong, they hardly can be put asunder. And each of them is admirable in its kind. For in every search for truth we can not only exercise curiosity, and have the delight—the really elemental happiness—of watching the unveiling of a mystery, but, on the way to truth, if we look well round us, we shall see that we are passing wonders more than the eye or mind can fully apprehend. And as one of the perfections of Nature is that in all her works wonder is harmonized with utility, so is it with our science. In every truth attained there is utility either at hand or among the certainties of the future. And this utility is not selfish: it is not in any degree correlative with money-making; it may generally be estimated in the welfare of others better than in our own. Some of us may indeed make money and grow rich; but many of those that minister even to the follies and vices of mankind can make much more money than we. In all things costly and vainglorious they would far surpass us if we would compete with them. We had better not compete where wealth is the highest evidence of success; we can compete with the world in

the nobler ambition of being counted among the learned and the good who strive to make the future better and happier than the past. And to this we shall attain if we will remind ourselves that, as in every pursuit of knowledge there is the charm of novelty, and in every attainment of truth utility, so in every use of it there may be charity. I do not mean only the charity which is in hospitals or in the service of the poor, great as is the privilege of our calling in that we may be its chief ministers; but that wider charity which is practiced in a constant sympathy and gentleness, in patience and self-devotion. And it is surely fair to hold that, as in every search for knowledge we may strengthen our intellectual power, so in every practical employment of it we may, if we will, improve our moral nature; we may obey the whole law of Christian love, we may illustrate the highest induction of scientific philanthropy.

Let us, then, resolve to devote ourselves to the promotion of the whole science, art, and charity of medicine. Let this resolve be to us as a vow of brotherhood; and may God help us in our work!—*Nature.*

INCREASE AND MOVEMENT OF THE COLORED POPULATION.

By J. STAHL PATTERSON.

II. MOVEMENT.

FOR the purpose of comparing the movement of the colored population before and since emancipation, we begin with the following table, which shows the percentage of colored increase in each of the slave States for the last decade of slavery:

STATES.	1850.	1860.	Gain per cent.	STATES.	1850.	1860.	Gain per cent.
Texas........	58,558	182,921	212·4	Tennessee.....	245,881	283,019	15·1
Arkansas......	47,708	111,259	133·2	North Carolina.	316,011	361,522	14·4
Florida........	40,242	62,677	55·8	Kentucky.....	220,992	236,167	6·9
Mississippi.....	310,808	437,404	40·7	Delaware......	20,363	21,627	6·2
Louisiana......	262,271	350,373	33·6	South Carolina.	393,944	412,320	4·7
Missouri.......	90,040	118,503	31·6	Virginia.......	526,861	548,907	4·2
Alabama.......	345,109	437,770	26·8	Dist. of Columb.	13,746	14,316	4·1
Georgia........	384,613	465,698	21·1	Maryland......	165,091	171,131	3·7

It will be observed that South Carolina and the border States added very little to their colored population during this decade. This was largely due to emigration, no doubt; and in most of these States this took opposite directions, part of it going southward by compulsion, and part of it northward by choice. Canada in a small way, and the new and great planting States of the South mainly, received the benefit of these tendencies of the colored movement.

The following table gives the colored increase of the same States

for the decade from 1860 to 1870, embracing the last three years of slavery and the first seven of freedom :

STATES.	1860.	1870.	Gain per cent.	STATES.	1860.	1870.	Gain per cent.
Dist. of Columb.	14,316	43,404	203·1	Delaware......	21,627	22,794	5·4
Florida........	62,677	91,689	46·3	Louisiana	350,373	364,210	4·0
Texas.........	182,921	253,475	38·6	Maryland......	171,131	175,391	2·5
Georgia........	465,698	545,142	17·1	Mississippi	437,404	444,201	1·5
Tennessee......	283,019	322,331	13·9	South Carolina.	412,320	415,814	0·9
Arkansas......	111,259	122,169	9·8	Missouri.......	118,503	118,071	0·4 loss
Alabama.......	437,770	475,510	8·6	Va. and W. Va.	548,907	530,821	3·3 "
North Carolina..	361,052	391,650	8·3	Kentucky......	236,167	222,210	5·9 "

The drift is mainly toward the two new States, Texas and Florida. A great change has come over the District of Columbia. From standing near the foot of the list in the previous table, it is now at the head. The freedmen found protection and encouragement, with a large demand for such labor as they are qualified to do, and hence they flocked to the District. The border States are worse off than during the previous decade, owing, no doubt, to the war and to the proximity of the old free States, in which the freedmen found more sympathy than among their former neighbors.

The following table shows the colored increase of the principal Northern States for the same decade, and shows what has become of a part of the freedmen :

STATES.	1860.	1870.	Gain per cent.	STATES.	1860.	1870.	Gain per cent.
Kansas........	627	17,108	2,628·5	Massachusetts..	9,602	13,947	45·3
Iowa..........	1,069	5,762	439·0	Rhode Island..	3,952	4,980	26·0
Illinois........	7,628	28,762	277·0	New Jersey....	25,336	30,658	21·0
Indiana	11,428	24,560	114·9	Pennsylvania ..	56,949	65,294	14·7
Michigan.......	6,799	11,849	74·3	Connecticut....	8,627	9,668	12·0
Ohio..........	36,673	63,213	72·4	New York.....	49,005	52,081	6·3

The aggregate increase in these twelve States was from 217,092 to 327,882, or 51·0 per cent., being 41 per cent. more than the average increase of all the colored in the United States for the same period. Only one State (New York) fell below this average.

The following table shows the increase of the colored population in the former slave States for the last decade, 1870 to 1880 :

STATES.	1870.	1880.	Gain per cent.	STATES.	1870.	1880.	Gain per cent.
Arkansas......	122,169	210,622	72·4	Louisiana	364,210	483,794	32·8
Texas.........	253,475	394,001	55·4	Alabama......	475,510	600,249	26·2
Mississippi.....	444,201	650,337	46·4	Tennessee.....	322,331	402,991	25·0
South Carolina..	415,814	604,275	45·3	Virginia.......	512,841	631,754	23·2
West Virginia..	17,980	25,806	43.5	Missouri	118,071	145,046	22·8
Florida........	91,689	125,464	36·8	Kentucky	222,210	271,461	22·2
Dist. of Columb.	43,404	59,378	36·8	Maryland......	175,391	209,897	19·7
North Carolina..	391,650	531,351	35·7	Delaware.....	22,794	26,450	16·0
Georgia........	545,142	724,685	32·9				

Usually, as population becomes more dense, its percentage of gain becomes less; but in the two Southern States, Mississippi and South Carolina, in which the colored population is densest and most largely outnumbering the white, the ratio of increase is among the greatest. Not even the principle of density, nor the terrors of the "Mississippi plan," appear to have exerted the least check upon the multiplication of the colored people in those States. They probably received some accessions from immigration, especially Mississippi, as Texas and Arkansas certainly did. The table indicates readily what States probably lost by emigration. The showing for South Carolina has been anomalous for the last three censuses, it having, like the border States, gained little during the seventh and eighth decades, but having gained enormously during the ninth, as shown by the last census, and yet in no State is the correctness of this census better assured than in South Carolina. If there be error it is in the previous census. The ratio of increase in seven of these States rises above the average for the colored population of the United States; North Carolina has the same ratio, while the others fall below it.

The following table gives the colored increase in twelve Northern States for the last decade:

STATES.	1870.	1880.	Gain per cent.	STATES.	1870.	1880.	Gain per cent.
Kansas........	17,108	43,096	151·9	Rhode Island..	4,980	6,503	30·6
Iowa..........	5,762	9,443	63·9	New Jersey....	30,658	38,796	26·5
Illinois........	28,762	46,248	60·8	Michigan......	11,849	14,986	26·5
Indiana........	24,560	38,998	58·8	Ohio..........	63,213	79,665	26·0
Massachusetts..	13,947	18,411	32·0	New York.....	52,081	64,969	24·7
Pennsylvania...	65,294	85,342	30·7	Connecticut....	9,668	11,428	18·2

During the decade the colored population in these twelve States increased from 327,882 to 458,185, being 39·9 per cent., a little above the ratio of increase for the entire colored population of the United States; but this was gained wholly in the first four States of the list, the percentage of gain in the remaining eight being about equal to the average gain of the white population in those States. The last two tables appear to indicate that the movement of the colored population is not great, but mainly toward the Southwestern States. And while only four of the Western States, Kansas, Iowa, Illinois, and Indiana, have received considerable accessions, the percentage of their gain being high, the aggregate number of immigrants northward is comparatively small. The last five States of the list seem to have lost a small portion of their colored population by emigration.

What is the law of colored migration? The colored man is actuated by the same motives in changing localities as any other man. Social attraction, sympathy, opportunity for paying employment, with facilities for reaching the new home—these determine the direction of his movement. Climate is, no doubt, a consideration which coöperates

with others in determining the general result, a warm climate being congenial to temperament and favorable to ease of living. In the South, the drift is to the new lands and the rich planting-regions; in the North, it is mainly to the accessible States in which employment is to be had. The tables of population by counties show that the colored people are very thoroughly distributed over the country, thinning out toward the North. In the same latitude the proportion of the colored population bears a very uniform relation to the number of whites. In tables giving the white and colored population of Northern States by counties, the adjacent columns, representing the two classes, indicate simply on their face this uniformity of relation. There are many exceptions, of course, as where, for example, in parts of New York, Pennsylvania, and New Jersey, there is a large proportion of Irish, the two races not harmonizing well together, since they are competitors for the same kinds of employment. There were 25 per cent. more colored in New York County in 1840 than in 1870; while in Hudson County, New Jersey, in which Jersey City is situated, there is far less than the usual proportion of the colored element. But the rule will hold in a general way, notwithstanding the exceptions by whatsoever caused.

It is not the habit of the colored people to look up a vacancy in some new State, and proceed to fill it with their own race. If they did they would have to be their own employers, and the prosperity of the community would be of their own making. On the contrary, they seem to find a place more congenial to their tastes and better adapted to their wants by the side of and among white people. Here they may get employment without making it for themselves. Instead, therefore, of dying out by the side of the white man under freedom, as has been supposed, they are really stronger to live there than they would be in a settlement of colored people alone. This is so necessarily where, as in the older States, capital is indispensable as the basis of employment. It would seem that, in the industrial aspects of the case, the white and colored man may be, under certain circumstances, the complement of each other.

What will be the direction of colored migration in the future? This will depend in part on the policy of States and of the General Government toward the colored people. Formerly it was a current speculation that the blacks would drift toward certain States in the South, which would pass under colored control in all respects, to the exclusion of the whites. This, however, is not likely to take place, except by interference of the General Government. If, under the pretext of a free ballot, the bayonet is resorted to by any party in power at Washington, and certain States in the South are again brought under the control of ignorant masses led by political adventurers, Southern society may be forced into a different form from that which now prevails. Under the continuance of such a policy, if it could be

maintained, certain States might become exclusively colored, and society therein sink toward a form of semi-barbarism. The white would eventually be driven out by political corruption, maladministration, and State bankruptcy. And let no man be deceived: if the native whites are compelled to abandon certain Southern localities on account of uninstructed colored predominance in local administration, the Yankee, or any other who is studious of thrift, will not take their place. Only a few sharpers, and the vultures in search of political carrion, will be found there. But this alternative of the "negro problem" is not likely to be adopted. Hardly any party is ready to go into history with such a policy, for, if it tripped, as it might, it would be bad for such party. It is the teaching of all history that those who have had freedom of self-rule have proved themselves competent to take it and hold it in spite of despots. This self-assertion is a necessary condition of freedom and its maintenance. There is no such thing as freedom under exotic tutelage. If a people who are numerically in the majority can only be secured in their political rights by national troops, then do such people illustrate political serfdom in becoming the tools of the party in power, and freedom becomes an abortion by the method used to secure it.

The problem, then, is to be determined on the presumption that local self-government in the South shall be in the hands of those who are competent to direct it; and that existing forces, under which the South has multiplied so rapidly in population during the last ten years, shall continue to operate.

Many of the planting-districts in the South contain already quite as large a colored population as is compatible with interest and comfort. This is thoroughly felt, if not clearly seen, by the colored people. They become the most dissatisfied with the situation, not where they are distributed among the whites in smaller numbers, but in districts where the colored population is greatest. Why so? Not on account of political terrorism by any means, but on account of the bad footing up at the close of the working-season. These are the places and this the reason which give rise to that recent phenomenon known as the "negro exodus." The tables indicate that there is emigration from most of the former border slave States. But the movement is individual, and not gregarious. It is undertaken with a rational view of what is to be gained by the change, much after the fashion of the whites, and it makes no noise in the newspapers as an "exodus." Among the simple-minded and impulsive masses farther South it is different. There it takes the form of a psychological epidemic, with only a vague and fanatical conception of what is ahead. We have only seen the beginning of this, perhaps, though the movement has its drawbacks. Not the most provident now leave the South; very generally, no doubt, the least so. Not the best hands come—often the worst. They have the old slave way, and the inaptitude for diversity

of labor, with characteristic indifference to their employers' interest. They are not generally satisfactory help. If they stay North, they live from hand to mouth, and when they die the town has to bury them. A few return to the warmer climate of the South where wants are less urgent and more easily supplied, and where the work to be done is simpler in form and better adapted to their habits. There is, therefore, a mild form of counter-exodus.

No doubt many portions even of the planting-regions in the older Southern States will admit of a still denser colored population. And while this continues to be the case no continuous heavy emigration is to be expected. But the filling-up process will go on, and, when there is crowding, relief will be had by emigration, if it is possible. The richest portions of the country South are breeding-lands, whence must flow increasing streams of colored migration, mainly to the westward, as the last census indicates. At any rate, they will flow in the direction of least resistance; and such are the forces which guide them, whether they flow westward or northward, that the people they bear become very thoroughly interdiffused among the whites. And while they are less thrifty than white people generally, all are not so. There are two distinct classes of colored economists. One is satisfied with dependence on others for employment; the other affects independent homes, and struggles to secure them, however humble. Some even acquire wealth. With wealth and independence will come greater respect. Gradually will the race-prejudice weaken. Now there are occasional marriages across the color-line; then they will be more frequent. This will accelerate the relative increase of the colored people, and the Caucasianizing of the colored race. Even now they are no longer negroes. One third has a large infusion of white blood, another third has less, but still some, and of the other third it would be difficult to find an assured specimen of pure African blood.

An English writer of distinction has found the solution of the American race question, in the blending of the white and colored elements, in the production of an improved type of man. We who are on the ground are generally skeptical as to the benefit thus to accrue; and it is not at all likely that amalgamation will ever be complete, under the reign of whatever physiological philosophy. Nature does not act in that thorough way; and philosophy does little to coerce Nature. Race prejudices and antipathies may abate, but they never wholly die out. Even after the plebeians and patricians might intermarry and the former be consuls, the patrician dames would relent none of their inherited scorn and antipathy for their plebeian rivals. Such prejudice is imbibed as unconsciously, but as surely, as nourishment from the mother's breast. It never ends. There will always be a colored race, of more uniform and lighter shade than at present, and always a white, even though branches of it perish in the fatal folds of luxury and dissipation. It will not end by amalgamation with the colored

race, nor change by absorbing it. Intermixture of the white and colored is destined, probably, to play a greater *rôle* than it now does; and this new race—for new it is—may greatly enlarge its proportion of numbers on American soil, but it is not to be expected that it will transcend in moral and intellectual elevation. It is probable that this mixed race which is forming in our country has greater capabilities than it generally gets credit for. In some respects its moral and social qualities may be quite as desirable in a race of mankind as the corresponding qualities in white men; but in intellect, in fertility of resource, in that which furthers progress and renders society and civilization exalted and refined, it is not likely that any compound with a fraction of Caucasian blood in it, will be equal to the Caucasian himself. In intellect, which, with Draper, we must regard as the leading and highest faculty of mind, it is not likely that any mixture of African blood, with all the advantages of development it may have, will ever equal the historical Teuton. And there is less to be hoped from the colored race in this country, because its progenitors on the African side are a low type even of Africans, as one of the race candidly admits (Rev. Edward W. Blyden, "a negro," "Fraser's Magazine"). Education may do a great deal, especially the education of practical life in connection with the more gifted Teuton; but with this spread of the colored element, if it should still continue, while it may itself experience a considerable degree of elevation, there must come a lowering, through this agency, of the average psychological level, and this can not take place without affecting the general tone of society. And it will so affect society, not only because of the relative gain of numbers, if that should be, but, paradoxical as it may seem, by virtue, also, of a certain degree of improvement which is above the lowest, but does not reach the highest, whereby the colored element will obtain a power in society, which, with fewer numbers and greater moral subordination, it did not before have. Then, indeed, will there be need of a "strong government," or, perhaps, it should rather be said, then will it be easy to establish a strong government.

ABOUT COMETS.

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THE study of astronomy reaches back to the very beginnings of history, and through all the ages the ablest intellects have been directed to the wellnigh impossible task of unraveling the celestial motions. The terrestrial observer not being located at the center of the motions of the solar system, the complexity arising from this com-

pounding of the motion of the observer with the motion of the planet observed rendered the problem very difficult.

Copernicus furnished the key, by showing that the sun and not the earth is the center of the solar system. Tycho Brahe soon followed, and furnished an extensive series of accurate observations that afforded Kepler the material upon which he based his studies that developed those immortal laws defining the forms of the orbits of the planets, the character of their motions, and the relation between the dimensions of their orbits and their periods of revolution.

It remained for Newton to discover the existence of the law of universal gravitation, of which Kepler's laws are an immediate sequence.

Thus the secrets of the motions of the planets were explained. But comets, those erratic visitants of our system, whose advent in olden time filled the mind with universal awe, were still an unfathomed mystery. Suddenly they would blaze out in the sky, and as suddenly pass out of sight, and no astronomer could tell whence they came or whither they went, or the laws which governed their motions.

Newton first showed that comets also were obedient to the attraction of gravitation. He demonstrated this fact by means of the comet of 1680. The orbit of this comet he found not to differ perceptibly from a parabola.

After Newton, Edmund Halley, from a careful study of the comets of 1531, 1607, and 1682, ventured the assertion that these were only different appearances of one and the same body, whose period of revolution was about seventy-five years. Halley, consequently, predicted a reappearance of this comet in 1759. This comet was shown to move in a very elongated ellipse. In accordance with prediction, reappearances of this comet occurred in 1759 and 1835.

Since the time of Newton all the comets which have come to view have been submitted to a careful study. To determine the orbit of any newly discovered member of our system, it is necessary that its direction in space from the earth at three dates, as nearly equidistant as may be, should be determined by observation.

The data for the problem are, then, as follows : the positions of the earth with reference to the sun at three different dates, and the positions of the heavenly body with reference to the earth at the same dates. The unknown elements which describe the character of the orbit and its position in space are as follows :

I. The mean longitude of the body at any convenient epoch.
II. The semi-major axis of the orbit.
III. The eccentricity of the orbit.
IV. The longitude of the perihelion.
V. The longitude of the ascending node.
VI. The inclination between the orbit-plane and the plane of the earth's orbit.

Of the above, I indicates the position of the body in the orbit at some definite time ; II gives the greatest semi-diameter of the ellipse ; III gives the ratio of the distance of the focus from the center divided by the semi-major axis ; IV, with VI, gives the position in space of the greatest diameter of the ellipse ; V gives the position of the line of intersection between the plane of the unknown orbit and the plane of the earth's orbit.

From II may be determined immediately the period of revolution by means of Kepler's law as follows: if a and a' are respectively the semi-major axis of the unknown orbit and the earth's orbit, and t and t' the respective periods of revolution, then we have from Kepler's law—

$$\frac{t^2}{a^3} = \frac{t'^2}{a'^3} \text{ and } t = \left(\frac{a^3 t'^2}{a^3}\right)^{\frac{1}{2}}.$$

If the eccentricity of the orbit is very large, the portion of the ellipse in the vicinity of the perihelion approximates to a parabola, which it becomes when the eccentricity equals unity.

As a matter of history, the great majority of comet orbits hitherto studied are either parabolas or are portions of excessively elongated ellipses, so as to be indistinguishable from parabolas, at least in the part of the orbit traversed during visibility. This portion of the orbit is always adjacent to the perihelion.

From the foregoing fact, and moreover because the computation of a parabolic orbit is much simpler, there being one less unknown quantity, preliminary comet orbits are always parabolic. Subsequent investigations show whether the comet deviates perceptibly from the parabola computed.

On October 10, 1880, Lewis Swift, of Rochester, New York, discovered a comet which has proved to be of peculiar interest. From its first discovery it has presented no brilliancy of appearance, for, during its period of visibility, a telescope of considerable power was necessary to observe it. Since this comet when in close proximity to the earth was very faint indeed, its dimensions must be quite moderate.

As soon after its apparition as the necessary observations of position were obtained, its parabolic elements were computed by several astronomers. After carefully comparing these elements with those of previous comets, Mr. S. C. Chandler, of Boston, remarked the striking similarity between them and those of Comet III of 1869. He immediately suspected them to be one and the same body, revolving in an elongated ellipse, having a period of eleven years, or a sub-multiple of eleven years.

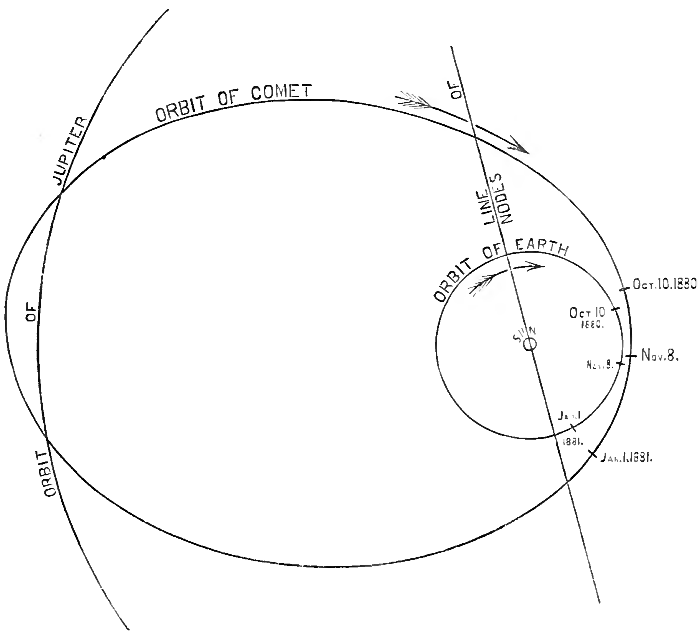
Mr. Chandler hereupon made some extended investigations, to determine which period was the more probable. He showed that the observed positions could be satisfied more closely with a period of five and one half years.

It seemed very desirable that elliptic elements should be determined for this comet without making any previous assumptions in reference to any of the elements ; this was undertaken independently by two astronomers of the United States Naval Observatory, each from different data. Professor Frisby made use of observations of October 25th, November 7th, and November 20th. Mr. Upton selected the following dates : October 25th, November 23d, and December 22d.

The results of these two computations agree very closely : the resulting period is only a few days less than six years. The inclination of the plane of the orbit to the plane of the ecliptic is about five and one half degrees.

To show more strikingly the remarkable situation of the comet's orbit with reference to the earth's orbit, the attention of the reader is directed to the accompanying diagram (Fig. 1), which, for the sake of

Fig. 1.



simplicity, shows the two orbits as if in one plane, when in reality the angle of inclination between them is about five and one half degrees. The line marked "line of nodes" is the line of their mutual intersection, the part of the comet's orbit in the vicinity of the perihelion being north of the plane of the ecliptic.

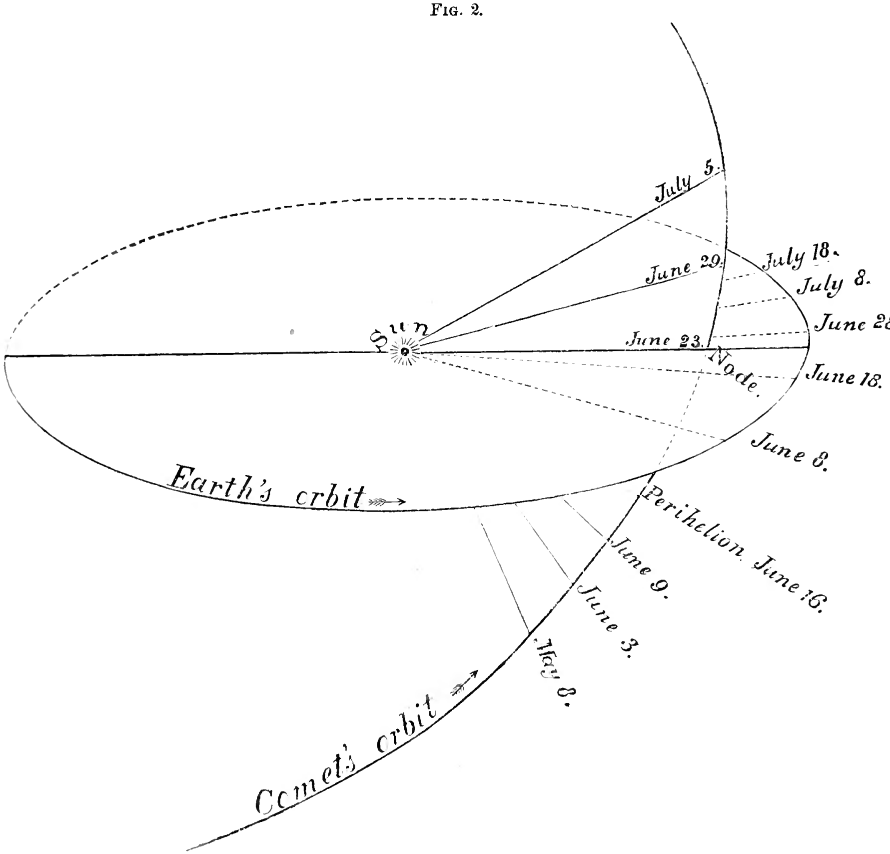
The relative situations of the earth and comet are shown by their positions in orbit at the date of discovery of the comet, October 10 ; the date of the perihelion passage, November 8, 1880, and January 1, 1881.

The nearest approach of the comet to the earth was about November 18, 1880, when it was distant from the earth 0·13 of the earth's distance from the sun. The period, as determined by Professor Frisby and Mr. Upton, is probably somewhat too large, owing to the uncertainty arising from the shortness of the arc of observation. The length of the period of revolution affords a reason for the fact that the comet escaped observation at its last return; since then it must have been in the direction of the sun.

It will be seen, from the drawing, that at aphelion the comet passes beyond the orbit of the planet Jupiter.

About the 22d of June last, a comet flashed into view which was unexpected as it was brilliant. It was seen with the unassisted eye by a multitude of persons in widely separated localities. Among the ear-

Fig. 2.



liest of those who discovered its presence in the northern sky was Mr. G. W. Simmons, of Boston, Massachusetts, who chanced to be in camp at Morales, Mexico. This gentleman first saw it on the morning of June 20th. It had, however, been discovered nearly one month earlier

by Mr. Tebbutt, of New South Wales, Australia, on May 22d. During the interval between these two dates it had moved northward through an arc of more than 60°, which rapid motion accounts for its sudden apparition in our northern sky.

The relative situation of the orbits of the comet and the earth will be best understood by the perspective view of a model of the two orbits constructed to scale (Fig. 2). This model was executed, from elements computed by Messrs. Chandler and Wendell, of Harvard College Observatory, by Ensign S. J. Brown, U. S. N., who kindly placed it at the service of the writer.

In this cut, the horizontal plane represents the position of the earth's orbit, and the plane cutting this at a large angle represents the plane of the comet's orbit. The comet moved from below, which is the southern side, up through the plane of the earth's orbit to the northern side. The dates indicate the positions of the earth and comet at different times in their respective orbits. It passed its perihelion point just before passing through the plane of the earth's orbit.

The orbit of the comet is inclined to the plane of the earth's orbit at an angle of 63°. Its perihelion distance is 0·77 of the earth's distance from the sun. It arrived at its perihelion June 16th, and was nearest the earth June 19th, when its distance from the earth was 0·28 of the earth's distance from the sun.

The nucleus attained fully the brightness of a first-magnitude star, and the length of the tail was variously estimated at from 20° to 30°. This comet is still faintly visible to the naked eye (August 22d).

At first it was suspected that this comet was identical with that of 1807, but later investigation disproved this supposition.

THE CONNECTION OF THE BIOLOGICAL SCIENCES WITH MEDICINE.*

By Professor T. H. HUXLEY.

THE great body of the theoretical and practical knowledge which has been accumulated by the labors of some eighty generations, since the dawn of scientific thought in Europe, has no collective English name to which an objection may not be raised; and I use the term "medicine" as that which is least likely to be misunderstood; though, as every one knows, the name is commonly applied, in a narrower sense, to one of the chief divisions of the totality of medical science.

* Address at the International Medical Congress, by Professor T. H. Huxley, LL. D., Secretary to the Royal Society.

Taken in this broad sense, "medicine" not merely denotes a kind of knowledge, but it comprehends the various applications of that knowledge to the alleviation of the sufferings, the repair of the injuries, and the conservation of the health, of living beings. In fact, the practical aspect of medicine so far dominates over every other, that the "healing art" is one of its most widely received synonyms. It is so difficult to think of medicine otherwise than as something which is necessarily connected with curative treatment, that we are apt to forget that there must be, and is, such a thing as a pure science of medicine—a "pathology" which has no more necessary subservience to practical ends than has zoölogy or botany.

The logical connection between this purely scientific doctrine of disease, or pathology, and ordinary biology, is easily traced. Living matter is characterized by its innate tendency to exhibit a definite series of the morphological and physiological phenomena which constitute organization and life. Given a certain range of conditions, and these phenomena remain the same, within narrow limits, for each kind of living thing. They furnish the normal and typical characters of the species; and, as such, they are the subject-matter of ordinary biology.

Outside the range of these conditions, the normal course of the cycle of vital phenomena is disturbed; abnormal structure makes its appearance, or the proper character and mutual adjustment of the functions cease to be preserved. The extent and the importance of these deviations frôm the typical life may vary indefinitely. They may have no noticeable influence on the general well-being of the economy, or they may favor it. On the other hand, they may be of such a nature as to impede the activities of the organism, or even to involve its destruction.

In the first case, these perturbations are ranged under the wide and somewhat vague category of "variations"; in the second, they are called lesions, states of poisoning, or diseases; and, as morbid states, they lie within the province of pathology. No sharp line of demarkation can be drawn between the two classes of phenomena. No one can say where anatomical variations end and tumors begin, nor where modification of function, which may at first promote health, passes into disease. All that can be said is, that whatever change of structure or function is hurtful belongs to pathology. Hence it is obvious that pathology is a branch of biology; it is the morphology, the physiology, the distribution, the etiology of abnormal life.

However obvious this conclusion may be now, it was nowise apparent in the infancy of medicine. For it is a peculiarity of the physical sciences, that they are independent in proportion as they are imperfect; and it is only as they advance that the bonds which really unite them all become apparent. Astronomy had no manifest connection with terrestrial physics before the publication of the "Principia";

that of chemistry with physics is of still more modern revelation; that of physics and chemistry with physiology has been stoutly denied within the recollection of most of us, and perhaps still may be.

Or, to take a case which affords a closer parallel with that of medicine. Agriculture has been cultivated from the earliest times, and from a remote antiquity men have attained considerable practical skill in the cultivation of the useful plants, and have empirically established many scientific truths concerning the conditions under which they flourish. But it is within the memory of many of us that chemistry on the one hand and vegetable physiology on the other attained such a stage of development that they were able to furnish a sound basis for scientific agriculture. Similarly, medicine took its rise in the practical needs of mankind. At first, studied without reference to any other branch of knowledge, it long maintained, indeed still to some extent maintains, that independence. Historically, its connection with the biological sciences has been slowly established, and the full extent and intimacy of that connection are only now beginning to be apparent. I trust I have not been mistaken in supposing that an attempt to give a brief sketch of the steps by which a philosophical necessity has become an historical reality, may not be devoid of interest, possibly of instruction, to the members of this great Congress, profoundly interested as all are in the scientific development of medicine.

The history of medicine is more complete and fuller than that of any other science, except, perhaps, astronomy; and, if we follow back the long record as far as clear evidence lights us, we find ourselves taken to the early stages of the civilization of Greece. The oldest hospitals were the temples of Æsculapius; to these Asclepeia, always erected on healthy sites, hard by fresh springs and surrounded by shady groves, the sick and the maimed resorted to seek the aid of the god of health. Votive tablets or inscriptions recorded the symptoms, no less than the gratitude, of those who were healed; and, from these primitive clinical records, the half-priestly, half-philosophic caste of the Asclepiads compiled the data upon which the earliest generalizations of medicine, as an inductive science, were based.

In this state, pathology, like all the inductive sciences at their origin, was merely natural history; it registered the phenomena of diseases, classified them, and ventured upon a prognosis, wherever the observation of constant coexistences and sequences suggested a rational expectation of the like recurrence under similar circumstances.

Further than this it hardly went. In fact, in the then state of knowledge, and in the condition of philosophical speculation at that time, neither the causes of the morbid state nor the *rationale* of treatment were likely to be sought for as we seek for them now. The anger of a god was a sufficient reason for the existence of a malady, and a dream ample warrantee for therapeutic measures; that a physical

phenomenon must needs have a physical cause was not the implied or expressed axiom that it is to us moderns.

The great man whose name is inseparably connected with the foundation of medicine, Hippocrates, certainly knew very little, indeed practically nothing, of anatomy or physiology; and he would probably have been perplexed even to imagine the possibility of a connection between the zoölogical studies of his contemporary, Democritus, and medicine. Nevertheless, in so far as he, and those who worked before and after him in the same spirit, ascertained, as matters of experience, that a wound, or a luxation, or a fever, presented such and such symptoms, and that the return of the patient to health was facilitated by such and such measures, they established laws of nature, and began the construction of the science of pathology. All true science begins with empiricism—though all true science is such exactly, in so far as it strives to pass out of the empirical stage into that of the deduction of empirical from more general truths. Thus, it is not wonderful that the early physicians had little or nothing to do with the development of biological science; and, on the other hand, that the early biologists did not much concern themselves with medicine. There is nothing to show that the Asclepiads took any prominent share in the work of founding anatomy, physiology, zoölogy, and botany. Rather do these seem to have sprung from the early philosophers, who were essentially natural philosophers, animated by the characteristically Greek thirst for knowledge as such. Pythagoras, Alcmeon, Democritus, Diogenes of Apollonia, are all credited with anatomical and physiological investigation; and though Aristotle is said to have belonged to an Asclepiad family, and not improbably owed his taste for anatomical and zoölogical inquiries to the teachings of his father, the physician Nicomachus, the "Historia Animalium," and the treatise "De Partibus Animalium," are as free from any allusion to medicine as if they had issued from a modern biological laboratory.

It may be added that it is not easy to see in what way it could have benefited a physician of Alexander's time to know all that Aristotle knew on these subjects. His human anatomy was too rough to avail much in diagnosis, his physiology was too erroneous to supply data for pathological reasoning. But when the Alexandrian schools, with Erasistratus and Herophilus at their head, turned to account the opportunities for studying human structure, afforded to them by the Ptolemies, the value of the large amount of accurate knowledge thus obtained to the surgeon for his operations, and to the physician for his diagnosis of internal disorders, became obvious, and a connection was established between anatomy and medicine, which has ever become closer and closer. Since the revival of learning, surgery, medical diagnosis, and anatomy have gone hand in hand. Morgagni called his great work, "De sedibus et causis morborum per anatomen indagatis," and not only showed the way to search out the localities and the

causes of disease by anatomy, but himself traveled wonderfully far upon the road. Bichat, discriminating the grosser constituents of the organs and parts of the body one from another, pointed out the direction which modern research must take; until, at length, histology, a science of yesterday, as it seems to many of us, has carried the work of Morgagni as far as the microscope can take us, and has extended the realm of pathological anatomy to the limits of the invisible world.

Thanks to the intimate alliance of morphology with medicine, the natural history of disease has, at the present day, attained a high degree of perfection. Accurate regional anatomy has rendered practicable the exploration of the most hidden parts of the organism, and the determination during life of morbid changes in them; anatomical and histological *post-mortem* investigations have supplied physicians with a clear basis upon which to rest the classification of diseases, and with unerring tests of the accuracy or inaccuracy of their diagnoses.

If men could be satisfied with pure knowledge, the extreme precision with which in these days a sufferer may be told what is happening, and what is likely to happen, even in the most recondite parts of his bodily frame, should be as satisfactory to the patient as it is to the scientific pathologist who gives him the information. But I am afraid it is not; and even the practicing physician, while nowise underestimating the regulative value of accurate diagnosis, must often lament that so much of his knowledge rather prevents him from doing wrong, than helps him to do right.

A scorner of physic once said that nature and disease may be compared to two men fighting, the doctor to a blind man with a club, who strikes into the *mêlée*, sometimes hitting the disease, and sometimes hitting nature. The matter is not mended if you suppose the blind man's hearing to be so acute that he can register every stage of the struggle and pretty clearly predict how it will end. He had better not meddle at all, until his eyes are opened—until he can see the exact position of the antagonists, and make sure of the effect of his blows. But that which it behooves the physician to see, not indeed with his bodily eye, but with clear intellectual vision, is a process, and the chain of causation involved in that process. Disease, as we have seen, is a perturbation of the normal activities of a living body; and it is, and must remain, unintelligible, so long as we are ignorant of the nature of these normal activities. In other words, there could be no real science of pathology until the science of physiology had reached a degree of perfection unattained, and indeed unattainable, until quite recent times.

So far as medicine is concerned, I am not sure that physiology, such as it was down to the time of Harvey, might as well not have existed. Nay, it is perhaps no exaggeration to say that, within the memory of living men, justly renowned practitioners of medicine and surgery

knew less physiology than is now to be learned from the most elementary text-book; and, beyond a few broad facts, regarded what they did know as of extremely little practical importance. Nor am I disposed to blame them for this conclusion; physiology must be useless, or worse than useless, to pathology, so long as its fundamental conceptions are erroneous.

Harvey is often said to be the founder of modern physiology; and there can be no question that the elucidations of the function of the heart, of the nature of the pulse, and of the course of the blood, put forth in the ever-memorable little essay "De motu cordis," directly worked a revolution in men's views of the nature and of the concatenation of some of the most important physiological processes among the higher animals; while, indirectly, their influence was perhaps even more remarkable.

But, though Harvey made this signal and perennially important contribution to the physiology of the moderns, his general conception of vital processes was essentially identical with that of the ancients; and, in the "Exercitationes de generatione," and notably in the singular chapter "De calido innato," he shows himself a true son of Galen and of Aristotle.

For Harvey, the blood possesses powers superior to those of the elements; it is the seat of a soul which is not only vegetative but also sensitive and motor. The blood maintains and fashions all parts of the body, "*idque summa cum providentia et intellectu in finem certum agens, quasi ratiocinio quodam uteretur.*"

Here is the doctrine of the "pneuma," the product of the philosophical mold into which the animism of primitive men ran in Greece, in full force. Nor did its strength abate for long after Harvey's time. The same ingrained tendency of the human mind to suppose that a process is explained when it is ascribed to a power of which nothing is known except that it is the hypothetical agent of the process, gave rise in the next century to the animism of Stahl; and, later, to the doctrine of a vital principle, that "asylum ignorantiæ" of physiologists, which has so easily accounted for everything and explained nothing, down to our own times.

Now the essence of modern as contrasted with ancient physiological science, appears to me to lie in its antagonism to animistic hypotheses and animistic phraseology. It offers physical explanations of vital phenomena, or frankly confesses that it has none to offer. And, so far as I know, the first person who gave expression to this modern view of physiology, who was bold enough to enunciate the proposition that vital phenomena, like all the other phenomena of the physical world, are, in ultimate analysis, resolvable into matter and motion, was René Descartes.

The fifty-four years of life of this most original and powerful thinker are widely overlapped, on both sides, by the eighty of Harvey, who

survived his younger contemporary by seven years, and takes pleasure in acknowledging the French philosopher's appreciation of his great discovery.

In fact, Descartes accepted the doctrine of the circulation as propounded by "Hervæus, médecin d'Angleterre," and gave a full account of it in his first work, the famous "Discours de la Méthode," which was published in 1637, only nine years after the exercitation "De motu cordis"; and, though differing from Harvey in some important points (in which, it may be noted, in passing, Descartes was wrong and Harvey right), he always speaks of him with great respect. And so important does the subject seem to Descartes, that he returns to it in the "Traité des Passions" and in the "Traité de l'Homme."

It is easy to see that Harvey's work must have had a peculiar significance for the subtile thinker, to whom we owe both the spiritualistic and the materialistic philosophies of modern times. It was in the very year of its publication, 1628, that Descartes withdrew into that life of solitary investigation and meditation of which his philosophy was the fruit. And, as the course of his speculations led him to establish an absolute distinction of nature between the material and the mental worlds, he was logically compelled to seek for the explanation of the phenomena of the material world within itself; and, having allotted the realm of thought to the soul, to see nothing but extension and motion in the rest of nature. Descartes uses "thought" as the equivalent of our modern term "consciousness." Thought is the function of the soul, and its only function. Our natural heat and all the movements of the body, says he, do not depend on the soul. Death does not take place from any fault of the soul, but only because some of the principal parts of the body become corrupted. The body of a living man differs from that of a dead man in the same way as a watch or other automaton (that is to say, a machine which moves of itself), when it is wound up and has in itself the physical principle of the movements which the mechanism is adapted to perform, differs from the same watch or other machine when it is broken, and the physical principle of its movement no longer exists. All the actions which are common to us and the lower animals depend only on the conformation of our organs and the course which the animal spirits take in the brain, the nerves, and the muscles; in the same way as the movement of a watch is produced by nothing but the force of its spring and the figure of its wheels and other parts.

Descartes's "Treatise on Man" is a sketch of human physiology, in which a bold attempt is made to explain all the phenomena of life, except those of consciousness, by physical reasonings. To a mind turned in this direction, Harvey's exposition of the heart and vessels as an hydraulic mechanism must have been supremely welcome.

Descartes was not a mere philosophical theorist, but a hard-working dissector and experimenter, and he held the strongest opinion respect-

ing the practical value of the new conception which he was introducing. He speaks of the importance of preserving health, and of the dependence of the mind on the body being so close that perhaps the only way of making men wiser and better than they are is to be sought in medical science. "It is true," says he, "that as medicine is now practiced, it contains little that is very useful; but, without any desire to depreciate, I am sure that there is no one, even among professional men, who will not declare that all we know is very little as compared with that which remains to be known; and that we might escape an infinity of diseases of the mind, no less than of the body, and even perhaps from the weakness of old age, if we had sufficient knowledge of their causes, and of all the remedies with which nature has provided us."* So strongly impressed was Descartes with this, that he resolved to spend the rest of his life in trying to acquire such a knowledge of nature as would lead to the construction of a better medical doctrine.† The anti-Cartesians found material for cheap ridicule in these aspirations of the philosopher: and it is almost needless to say that, in the thirteen years which elapsed between the publication of the "Discours" and the death of Descartes, he did not contribute much to their realization. But, for the next century, all progress in physiology took place along the lines which Descartes laid down.

The greatest physiological and pathological work of the seventeenth century, Borelli's treatise "De motu animalium," is, to all intents and purposes, a development of Descartes's fundamental conception; and the same may be said of the physiology and pathology of Boerhaave, whose authority dominated in the medical world of the first half of the eighteenth century.

With the origin of modern chemistry and of electrical science in the latter half of the eighteenth century, aids in the analysis of the phenomena of life, of which Descartes could not have dreamed, were offered to the physiologist. And the greater part of the gigantic progress which has been made in the present century, is a justification of the prevision of Descartes. For it consists, essentially, in a more and more complete resolution of the grosser organs of the living body into physico-chemical mechanisms.

"I shall try to explain our whole bodily machinery in such a way that it will be no more necessary for us to suppose that the soul produces such movements as are not voluntary than it is to think that there is in a clock a soul which causes it to show the hours."‡ These words of Descartes might be appropriately taken as a motto by the author of any modern treatise on physiology.

But, though, as I think, there is no doubt that Descartes was the first to propound the fundamental conception of the living body as a physical mechanism, which is the distinctive feature of modern as

* "Discours de la Méthode," 6e partie, Ed. Cousin, p. 193. † Ibid., pp. 193, 211.

‡ "De la Formation du Fœtus."

contrasted with ancient physiology, he was misled by the natural temptation to carry out, in all its details, a parallel between the machines with which he was familiar, such as clocks and pieces of hydraulic apparatus, and the living machine. In all such machines there is a central source of power, and the parts of the machine are merely passive distributors of that power. The Cartesian school conceived of the living body as a machine of this kind; and herein they might have learned from Galen, who, whatever ill use he may have made of the doctrine of "natural faculties," nevertheless had the great merit of perceiving that local forces play a great part in physiology.

The same truth was recognized by Glisson, but it was first prominently brought forward in the Hallerian doctrine of the "vis insita" of muscles. If muscle can contract without nerve, there is an end of the Cartesian mechanical explanation of its contraction by the influx of animal spirits.

The discoveries of Trembley tended in the same direction. In the fresh-water *Hydra* no trace was to be found of that complicated machinery upon which the performance of the functions in the higher animals was supposed to depend. And yet the hydra moved, fed, grew, multiplied, and its fragments exhibited all the powers of the whole. And, finally, the work of Caspar F. Wolff,* by demonstrating the fact that the growth and development of both plants and animals take place antecedently to the existence of their grosser organs, and are, in fact, the causes and not the consequences of organization (as then understood), sapped the foundations of the Cartesian physiology as a complete expression of vital phenomena.

For Wolff, the physical basis of life is a fluid, possessed of a "vis essentialis" and a "solidescibilitas," in virtue of which it gives rise to organization; and, as he points out, this conclusion strikes at the root of the whole iatro-mechanical system.

In this country the great authority of John Hunter exerted a similar influence; though it must be admitted that the two sibylline utterances which are the outcome of Hunter's struggles to define his conceptions are often susceptible of more than one interpretation. Nevertheless, on some points Hunter is clear enough. For example, he is of opinion that "spirit is only a property of matter" ("Introduction to Natural History," p. 6), he is prepared to renounce animism (*loc. cit.*, p. 8), and his conception of life is so completely physical that he thinks of it as something which can exist in a state of combination in the food. "The aliment we take in has in it, in a fixed state, the real life; and this does not become active until it has got into the lungs; for there it is freed from its prison" ("Observations on Physiology," p. 113). He also thinks that "it is more in accord with the general principles of the animal machine to suppose that none of its effects are produced from any mechanical principle what-

* "Theoria Generationis," 1759.

ever; and that every effect is produced from an action in the part; which action is produced by a stimulus upon the part which acts, or upon some other part with which this part sympathizes so as to take up the whole action" (*loc. cit.*, p. 152).

And Hunter is as clear as Wolff, with whose work he was probably unacquainted, that "whatever life is, it most certainly does not depend upon structure or organization" (*loc. cit.*, p. 114).

Of course, it is impossible that Hunter could have intended to deny the existence of purely mechanical operations in the animal body. But while, with Borelli and Boerhaave, he looked upon absorption, nutrition, and secretion as operations effected by means of the small vessels, he differed from the mechanical physiologists, who regarded these operations as the result of the mechanical properties of the small vessels, such as the size, form, and disposition of their canals and apertures. Hunter, on the contrary, considers them to be the effect of properties of these vessels which are not mechanical, but vital. "The vessels," says he, "have more of the polypus in them than any other part of the body," and he talks of the "living and sensitive principles of the arteries," and even of the "dispositions or feelings of the arteries. . . . When the blood is good and genuine the sensations of the arteries, or the dispositions for sensation, are agreeable. . . . It is then they dispose of the blood to the best advantage, increasing the growth of the whole, supplying any losses, keeping up a due succession, etc." (*loc. cit.*, p. 133).

If we follow Hunter's conceptions to their logical issue, the life of one of the higher animals is essentially the sum of the lives of all the vessels, each of which is a sort of physiological unit, answering to a polyp; and, as health is the result of the normal "action of the vessels," so is disease an effect of their abnormal action. Hunter thus stands in thought, as in time, midway between Borelli on the one hand and Bichat on the other.

The acute founder of general anatomy, in fact, outdoes Hunter in his desire to exclude physical reasonings from the realm of life. Except in the interpretation of the action of the sense-organs, he will not allow physics to have anything to do with physiology.

"To apply the physical sciences to physiology is to explain the phenomena of living bodies by the laws of inert bodies. Now, this is a false principle, hence all its consequences are marked with the same stamp. Let us leave to chemistry its affinity, to physics its elasticity and its gravity. Let us invoke for physiology only sensibility and contractility." *

Of all the unfortunate dicta of men of eminent ability this seems one of the most unhappy, when we think of what the application of the methods and the data of physics and chemistry has done toward bringing physiology into its present state. It is not too much to say

* "Anatomie Générale," t. i, p. 54.

that one half of a modern text-book of physiology consists of applied physics and chemistry; and that it is exactly in the exploration of the phenomena of sensibility and contractility that physics and chemistry have exerted the most potent influence.

Nevertheless, Bichat rendered a solid service to physiological progress by insisting upon the fact that what we call life, in one of the higher animals, is not an indivisible unitary archæus dominating, from its central seat, the parts of the organism, but a compound result of the synthesis of the separate lives of those parts.

"All animals," says he, "are assemblages of different organs, each of which performs its function and concurs, after its fashion, in the preservation of the whole. They are so many special machines in the general machine which constitutes the individual. But each of these special machines is itself compounded of many tissues of very different natures, which in truth constitute the elements of those organs" (*loc. cit.*, lxxix). "The conception of a proper vitality is applicable only to these simple tissues, and not to the organs themselves" (*loc. cit.*, lxxxiv).

And Bichat proceeds to make the obvious application of this doctrine of synthetic life, if I may so call it, to pathology. Since diseases are only alterations of vital properties, and the properties of each tissue are distinct from those of the rest, it is evident that the diseases of each tissue must be different from those of the rest. Therefore, in any organ composed of different tissues, one may be diseased and the other remain healthy; and this is what happens in most cases (*loc. cit.*, lxxxv).

In a spirit of true prophecy, Bichat says, "We have arrived at an epoch, in which pathological anatomy should start afresh." For as the analysis of the organs had led him to the tissues, as the physiological units of the organism; so, in a succeeding generation, the analysis of the tissues led to the cell as the physiological element of the tissues. The contemporaneous study of development brought out the same result, and the zoölogists and botanists exploring the simplest and the lowest forms of animated beings confirmed the great induction of the cell theory. Thus the apparently opposed views, which have been battling with one another ever since the middle of the last century, have proved to be each half the truth.

The proposition of Descartes that the body of a living man is a machine, the actions of which are explicable by the known laws of matter and motion, is unquestionably largely true. But it is also true that the living body is a synthesis of innumerable physiological elements, each of which may nearly be described, in Wolff's words, as a fluid possessed of a "vis essentialis," and a "solidescibilitas"; or, in modern phrase, as protoplasm susceptible of structural metamorphosis and functional metabolism; and that the only machinery, in the precise sense in which the Cartesian school understood mechanism, is that

which coördinates and regulates these physiological units into an organic whole.

In fact, the body is a machine of the nature of an army, not of that of a watch, or of an hydraulic apparatus. Of this army, each cell is a soldier, an organ a brigade, the central nervous system headquarters and field telegraph, the alimentary and circulatory system the commissariat. Losses are made good by recruits born in camp, and the life of the individual is a campaign, conducted successfully for a number of years, but with certain defeat in the long-run.

The efficacy of an army, at any given moment, depends on the health of the individual soldier, and on the perfection of the machinery by which he is led and brought into action at the proper time; and, therefore, if the analogy holds good, there can be only two kinds of diseases, the one dependent on abnormal states of the physiological units, the other on perturbation of their coördinating and alimentative machinery.

Hence, the establishment of the cell theory, in normal biology, was swiftly followed by a "cellular pathology," as its logical counterpart. I need not remind you how great an instrument of investigation this doctrine has proved in the hands of the man of genius, to whom its development is due; and who would probably be the last to forget that abnormal conditions of the coördinative and distributive machinery of the body are no less important factors of disease.

Henceforward, as it appears to me, the connection of medicine with the biological sciences is clearly defined. Pure pathology is that branch of biology which defines the particular perturbation of cell-life, or of the coördinating machinery, or of both, on which the phenomena of disease depend.

Those who are conversant with the present state of biology will hardly hesitate to admit that the conception of the life of one of the higher animals as the summation of the lives of a cell aggregate, brought into harmonious action by a coördinative machinery formed by some of these cells, constitutes a permanent acquisition of physiological science. But the last form of the battle between the animistic and the physical views of life is seen in the contention whether the physical analysis of vital phenomena can be carried beyond this point or not.

There are some to whom living protoplasm is a substance even such as Harvey conceived the blood to be, "*summa cum providentia et intellectu in finem certum agens, quasi ratiocinio quodam*"; and who look, with as little favor as Bichat did, upon any attempt to apply the principles and the methods of physics and chemistry to the investigation of the vital processes of growth, metabolism, and contractility. They stand upon the ancient ways; only, in accordance with that progress toward democracy which a great political writer has declared to be the fatal characteristic of modern times, they substitute a repub-

lic formed by a few billion "animulæ" for the monarchy of the all-pervading "anima."

Others, on the contrary, supported by a robust faith in the universal applicability of the principles laid down by Descartes, and seeing that the actions called "vital" are, so far as we have any means of knowing, nothing but changes of place of particles of matter, look to molecular physics to achieve the analysis of the living protoplasm itself into a molecular mechanism. If there is any truth in the received doctrines of physics, that contrast between living and inert matter, on which Bichat lays so much stress, does not exist. In nature, nothing is at rest, nothing is amorphous; the simplest particle of that which men in their blindness are pleased to call "brute matter" is a vast aggregate of molecular mechanisms, performing complicated movements of immense rapidity and sensitively adjusting themselves to every change in the surrounding world. Living matter differs from other matter in degree and not in kind; the microcosm repeats the macrocosm; and one chain of causation connects the nebulous original of suns and planetary systems with the protoplasmic foundation of life and organization.

From this point of view, pathology is the analogue of the theory of perturbations in astronomy; and therapeutics resolves itself into the discovery of the means by which a system of forces competent to eliminate any given perturbation may be introduced into the economy. And, as pathology bases itself upon normal physiology, so therapeutics rests upon pharmacology; which is, strictly speaking, a part of the great biological topic of the influence of conditions on the living organism and has no scientific foundation apart from physiology.

It appears to me that there is no more hopeful indication of the progress of medicine toward the ideal of Descartes than is to be derived from a comparison of the state of pharmacology, at the present day, with that which existed forty years ago. If we consider the knowledge positively acquired, in this short time, of the *modus operandi* of urari, of atropia, of physostigmin, of veratria, of casca, of strychnia, of bromide of potassium, of phosphorus, there can surely be no ground for doubting that, sooner or later, the pharmacologist will supply the physician with the means of affecting, in any desired sense, the functions of any physiological element of the body. It will, in short, become possible to introduce into the economy a molecular mechanism which, like a very cunningly contrived torpedo, shall find its way to some particular group of living elements, and cause an explosion among them, leaving the rest untouched.

The search for the explanation of diseased states in modified cell-life; the discovery of the important part played by parasitic organisms in the etiology of disease; the elucidation of the action of medicaments by the methods and the data of experimental physiology; appear to me to be the greatest steps which have ever been made

toward the establishment of medicine on a scientific basis. I need hardly say they could not have been made except for the advance of normal biology.

There can be no question, then, as to the nature or the value of the connection between medicine and the biological sciences. There can be no doubt that the future of pathology and of therapeutics, and therefore that of practical medicine, depends upon the extent to which those who occupy themselves with these subjects are trained in the methods and impregnated with the fundamental truths of biology.

And, in conclusion, I venture to suggest that the collective sagacity of this congress could occupy itself with no more important question than with this: How is medical education to be arranged, so that, without entangling the student in those details of the systematist which are valueless to him, he may be enabled to obtain a firm grasp of the great truths respecting animal and vegetable life, without which, notwithstanding all the progress of scientific medicine, he will still find himself an empiric?

PROGRESS IN THE MANUFACTURE OF STEEL.*

By Professor A. K. HUNTINGTON.

IMPROVEMENTS in the arts and sciences have gradually modified the methods of producing iron and steel, and, in their turn, the arts and sciences have felt the reaction; for all improvements in the manufacture of iron and steel have consisted, not so much in the production of a better quality of the article, as in the cheapening of production by the application of the principles indicated by the progress of science, and by the use of superior machinery. The direct result of this cheapening has been to extend the applications of the products in the arts.

The discovery of steel appears to have naturally followed that of the means of reducing iron from its ore. In all primitive methods of iron-smelting, steel, in more or less quantity, is inevitably produced. Such methods have been carried on in India and Africa from time immemorial to the present day. A furnace of a similar primitive character has, for several centuries, been employed in Catalonia, in Spain.

In working this furnace, the ore is crushed by the hammer, and divided by sifting into lumps (*mine*) and very coarse powder (*greillade*). The furnace being still red-hot from the last operation, it is filled with charcoal nearly to the *tuyère*, the hearth is then divided at a point about two thirds distance from the tuyère into two parts by a broad shovel; on the blast-side a further quantity of char-

* Abridged from an address delivered before the London Society of Arts.

coal is added, while the coal on the other side having been rammed down firm, ore is added, so as to fill that part of the furnace; on this is placed moistened charcoal-dust, except at the top. A good blast is then turned on, and, if the whole is in proper order, jets of blue flame at once issue from the uncovered portion of the ore.

During the whole of the process, at short intervals, greillade and charcoal are added, and well moistened with water, to prevent too rapid combustion. After about two hours from the commencement, the wall of mine, i. e.—ore in lumps—is pushed well forward under the tuyère, and more mine is thrown into the space thus made; this part of the process is also subsequently repeated at intervals, until sufficient has been added to form a lump of iron or *massé* of the required size. From time to time slag is removed by opening the tap-hole. At the completion of the process, a mass of metal is obtained weighing about three hundred-weight, which invariably consists partly of soft iron, and partly of steely iron and steel.

The ore on one side of the furnace being in lumps, the hot carbonic oxide generated by the action of the blast on the charcoal is able to pass freely through its mass, reducing it, after the water has been driven off by heat, to metallic iron. At the same time the ore becomes impregnated with carbon, derived from the decomposition of the gases with which it is charged. The greillade on the other side is much richer in silica than the larger pieces, and from this it results that the quantity of slag will vary with the greillade added. It is always very rich in oxide of iron. It appears that in this process, carburized iron is produced by the gradual reduction and fusion of the lumps of ore, and this, coming in contact at the bottom of the furnace with slag, very rich in oxide of iron, the carbon of the one combines with the oxygen of the other, and the result is that iron containing more or less carbon is produced, according as much or little oxide was present.

In order that steel may be produced by this process, every precaution is taken to cause as much carburization as possible; the unavoidable presence of oxide of iron in the slag, and the low temperature, effectually preventing the formation of cast-iron; the former, indeed, making it very difficult to obtain steel.

Rightly looked at, this process explains how steel was first obtained, and what the essential conditions are in its production. When, owing to the increased size of blast-furnaces, and the consequent increase of temperature, cast-iron became the only product, it naturally followed that this substance should be treated with a view to the production of steel. This was first effected in the refining hearth, and formed an important industry in Styria, Carinthia, the Tyrol, and other places, in some of which it is still carried on. The operation was conducted in a finery, similar in construction to those employed in the production of iron—in fact, iron and steel are often produced

alternately in the same finery. This furnace, in its simplest form, consists essentially of a shallow quadrangular hearth, formed of cast-iron plates. In one side is a tuyère, inclined at an angle of 10° to 15°. The bottom is kept covered with a layer of charcoal. In the Siegen district, a piece of pig-iron, weighing fifty to sixty pounds, is placed on the hearth, having been previously heated; the hearth is then three parts filled with burning charcoal; on it is placed a portion of the cake produced in the last operation, which has been kept hot in burning charcoal, at the back of the furnace. The remainder of the hearth is then filled up with charcoal. The other six or seven pieces into which the last cake was divided are placed on the top. In this process, the production of steel and the reheating of that obtained in the last operation, preparatory to working it under the hammer, are conducted together. The blast is turned on. The piece of pig-iron forms into a pasty mass; cinder, rich in oxide of iron, produced in the latter part of the preceding operation, is then thrown in; a second piece of pig-iron, weighing about one hundred pounds, is added, and afterward four or five pieces of *spiegeleisen* (cast-iron, containing manganese), weighing each about a hundred pounds, are successively added. If the metal is found to be too much decarburized, more spiegel is added. In this process, as in the Catalan, it is impossible to obtain a homogeneous product. The principle in both is essentially the same, viz., decarburization by oxide of iron. In this process, as in every other process for the production of steel, manganese is used with great advantage—an advantage which arises from its power of replacing iron in the slag and of forming a slag that is more liquid than one containing iron alone.

The essential difference between the finery and the puddling process consists in the use of a reverberatory furnace, the manipulation of the metal and the regulation of the temperature being thereby greatly facilitated. The decarburization is effected by the addition of oxide of iron produced during rolling, and partially by the air which enters the furnace as the metal melts slowly down; manganese is added during the process. It is important that the temperature should be kept low. It is difficult to weld this steel perfectly, because, probably, the temperature at which it has to be worked is too low to make the cinder sufficiently liquid to enable it to be squeezed out under the hammer to the same extent that it is in the case of malleable iron. This difficulty has, however, been got over by completely fusing the steel before working it, so as to enable the slag to separate completely. In this form metal manufactured by this process has been largely used by Krupp.

The principle which regulates the production of steel by these methods is taken advantage of in the Uchatius process, in which pig-iron is first granulated by running it while molten into cold water. The granulated metal is then mixed with about twenty per cent. of roasted

spathic ore, crushed fine; the mixture, to which a little flux has been added, if necessary, is then fused in clay crucibles. If very soft steel is required, some wrought-iron scrap is added.

Lastly, in this category we have a process which consists in heating cast-iron, but not so as to soften it, in oxide of iron, in the form of ore or iron-scale. In this way partial, or even total, decarburization of the metal can be produced at will.

So far the difference between iron and steel has seemed to be merely one of degree, depending on the amount of carburization. The methods we have considered are, in fact, only modifications of those practiced for the production of malleable iron. We will now consider the different processes that have for their object to impart a certain amount of carbon to malleable iron. The Hindoos have practiced one of them from time immemorial. They place in unbaked-clay crucibles, of the capacity of a pint, a piece of malleable iron, some chopped wood, and a few leaves of certain plants; the top of the crucible is then closed with clay, and the whole well dried near a fire. A number of these crucibles are then strongly heated for about four hours in a cavity in the ground, by means of charcoal and a blast of air forced in by a bellows. There is some reason to believe that an excess of carbon, over that required to produce the hardest steel, has to be added, in order to fuse the metal at the temperature which can be commanded in these furnaces. Before being drawn out into bars, the cakes of metal obtained in this way are exposed in a charcoal-fire during several hours to a temperature a little below their melting-point, the blast of air playing upon them during the time. The object of this is, doubtless, to remove the excess of carbon.

In 1800 a patent was taken out by David Mushet for a process in every respect analogous to that just referred to. He appears, however, to have applied it to the manufacture of a metal low in carbon, and therefore intermediate between iron and steel, partaking in a certain degree of the properties of both.

In another method referred to by Biringuccio, in 1540, steel was produced by keeping malleable iron in molten cast-iron until it became pasty, and on examination was found to possess the properties of steel. In connection with the theory of steel manufacture this process is of great interest. It shows that iron in a strongly heated condition is capable of absorbing carbon by direct contact, unless we suppose that the carburization is effected by dissolved gases, which is possible.

In the cementation process, which was well described by Réaumur, in 1722, bars of iron are kept at a glowing red heat, surrounded with charcoal in boxes, into which the air is prevented from entering. The operation lasts from seven to ten days, according to the quality of steel required. These bars are never uniformly carburized, and, besides, they contain cinder, as the metal has never been fused. The

process had been a long time in use, however, before it occurred to any one to fuse the steel and make it homogeneous. This was done by Huntsman, about 1760.

By all the processes we have so far reviewed, good steel could be produced, but only in small quantity and at great expense. The applications of steel were, in consequence, very limited; in fact, practically, its use was confined to implements with a cutting edge.

In 1845 Heath patented a process which, had it been successful, would have given him the power of producing steel in quantity. He proposed to melt scrap-iron in a bath of molten pig iron in a reverberatory furnace heated by jets of gas. There were two conditions wanting in this method, which caused it to be a failure, viz., a sufficiently high temperature, and the power easily to regulate the character of the gases employed. Nevertheless, in this suggestion is to be found the germ of one of the two most important processes of the present day.

The dominant idea in treating cast-iron for steel had always been to refine the metal by the action of atmospheric air, and this was effected by causing a current of air to impinge upon the surface of the metal, by means either of a blowing apparatus or the drawing action of a chimney-stack. What more natural than that it should occur to some one to refine iron by blowing air into it, instead of merely on to its surface? We find that this idea did occur to several persons, widely separated, in the year 1855.

In this year a patent was taken out by John Gilbert Martien for refining iron, by forcing air through it as it flowed from the blast-furnace, or cupola, along runners to the puddling-furnace. The process, as detailed in the patent, was impracticable, and showed internal evidence of not having been worked out on a manufacturing scale. Just after this patent was taken out, we find George Parry, of the Ebbw Vale Works, making the experiment of forcing air through molten cast-iron, on the bed of a reverberatory furnace, by means of perforated pipes imbedded in the fire-clay bottom. Vigorous action is said to have taken place; but the metal, through an accident, escaped from the furnace, and the further trial of the process was discouraged by the managing director. Two or three months after these experiments, Henry Bessemer took out his now celebrated patent for the production of cast-steel by blowing air through molten cast-iron; it should be clearly borne in mind that he had been, for a considerable time previously, engaged in experiments on the subject. He first carried out his process in crucibles, placed in furnaces, and so arranged that the contents could be tapped from the bottom into molds. Steam or air, either separately or together, and by preference raised to a high temperature, was forced down into the crucible through a pipe. The patent goes on to state that steam cools the metal, but air causes a rapid increase in its temperature, and it passes from a red to

an intense white heat. Bessemer at first used extraneous heat to start the process, if not, indeed, during its progress, which shows that he was not then aware that the heat created by merely blowing in air would be sufficient. In his next patent he dispensed with the furnace around the crucible, and, instead of tapping the crucible from the bottom, he mounted it on trunnions, and, by tipping it up by machinery, poured the contents from the mouth. This apparatus is essentially the same as that used at the present day. It was soon found that, to produce steel by this process which would work properly, manganese, if not originally present, would have to be added. In the absence of manganese, sulphur and oxygen, in anything more than very minute quantities, make the steel crumble when worked at a red heat; it is said to be "red short." In the case of the oxygen, the manganese combines with it, and passes it into the slag; but with sulphur the reaction is different; its injurious effect is simply counteracted by the manganese: it is not removed from the steel. At first manganese was only employed in the form of spiegeleisen; but this use was liable to the difficulty that if enough spiegel was added to impart the requisite quantity of manganese, too much carbon would have been introduced, and alloys richer in manganese—known as ferro-manganese—have been sought and found.

By adding at the end of the process a known quantity of spiegel or ferro-manganese, containing a known quantity of carbon, steel of any required hardness could be obtained.

The year which saw the birth of the Bessemer process was doubly remarkable, for it was at that time that the regenerative system of heating was first introduced by Dr. Siemens. Nothing can be simpler than the principle involved in this method, yet it was destined to play a most important part in the progress of the arts. The idea was to store up the heat escaping in the waste gases from furnaces, and to employ it to raise the temperature of the gas and air previous to their combustion in the furnace. This was accomplished by causing the spent gases to pass through two chambers filled with loose brickwork. When these chambers have become heated to a high temperature, the waste gases are made to pass through two other similar chambers, and the air and gas necessary for combustion in the furnace are caused to pass through the highly heated regenerators. By causing the ingoing gases to pass alternately, at suitable intervals of time, through each pair of regenerators, a very high and, at the same time, uniform temperature can be obtained in the furnace, without any greater consumption of fuel than in the older methods. The success of this process depended entirely on the fuel being first converted into a combustible gas. This was done in a chamber to which only sufficient air is admitted to convert the carbon into carbonic oxide, which is then conducted by tubes to one of the regenerators to be heated, and thence to the furnace, where, coming in contact with air which has

been passed through the other regenerator, it burns, giving out intense heat.

There are two methods now in use for the production of steel in the reverberatory furnace, or open-hearth, as it is called. In France, pig-iron and scrap-steel are fused together; in England, pig-iron is decarburized by means of iron-ore, some scrap, however, being generally added for the sake of utilizing it. As in the Bessemer process, the necessary amount of carbon is imparted to the metal by the means of spiegeleisen or ferro-manganese. This process has been largely employed for the production of ship and boiler plates. It has the great advantage that the metal can be kept fluid on the hearth, and its composition adjusted until it is exactly that required.

In 1876 a patent was taken out by M. Pernot, in which it was proposed to produce steel on an open-hearth furnace with a revolving bed, inclined at an angle of 5° or 6° to the vertical. Pig-iron previously heated to redness is placed in the bed of the furnace and covered with scrap-steel. The bed of the furnace is then made to revolve slowly, the pig gradually melts, and the scrap is alternately exposed to the strong heat of the flame, and then dipped under the molten pig-iron. In this way the fusion is very rapid, comparatively, the whole mass becoming fluid in about two hours. The process is then completed in the ordinary way. M. Pernot informs me that he has just taken out a patent for an arrangement of his furnace by means of which he can employ gas under pressure, and that within the last few months he has obtained by this means results which have never been equaled before.

The Ponsard furnace aims at combining the advantages of the Bessemer and open-hearth processes. The furnace is so arranged that, by giving it a half-revolution on its oblique axis, the tuyères with which it is supplied may be brought either beneath or above the surface of the bath of metal. By these means the metal can be rapidly decarburized nearly entirely, as in the Bessemer converter, and then, by removing the tuyères from beneath the metal, the final adjustment of the carbon can be made as in the Siemens process. The rapid destruction of the tuyères which is effected is a formidable obstacle to the practical success of this process.

The one important drawback to the Bessemer process was that phosphorus was not in any degree eliminated by it. Notwithstanding this, enormous quantities of steel were made by it; and, within the last three years, means have been devised in the Thomas-Gilchrist, or "basic" process, by which this difficulty has been overcome. In the ordinary Bessemer converter the lining was formed of *ganister*, a siliceous material, the chemical effect of which was to prevent the elimination of phosphoric acid. Messrs. Thomas and Gilchrist sought a basic material which they could substitute for the ganister, and found a magnesian limestone which worked very satisfactorily. The

result of the application has been, that phosphorus has been converted from an enemy into a friend, and aids in producing and maintaining the temperature that is needed. Silicon is also useful as a combustible, and in preventing the metal from becoming honeycombed by escaping gases while solidifying. This it does by combining with oxygen and preventing the latter substance from combining with carbon and forming a gaseous product.

In consequence of the extremely high temperature which we can command, either in the Bessemer or open-hearth process, it is possible to obtain in a molten state a metal practically free from carbon, or containing carbon to any required amount. All of the products have been called steel, although they constitute in effect a new metal, having qualities considerably different from those of steel.

It thus has resulted that we speak of steel ships, steel boilers, and steel rails. The metal of which ship-plates are made contains about $\frac{13}{100}$ per cent. of carbon, that for boilers about $\frac{24}{100}$, while rails usually have about $\frac{4}{10}$. The first and the second could not be appreciably hardened, and the third is considerably below what would formerly have been considered steel.

At present there is but one sound reason why steel should not universally replace iron with advantage, and that is, that in some cases it is cheaper to employ iron. Statistics show us that the enormous quantities of steel now manufactured have but little, if at all, affected the production of wrought-iron. It is, however, I am convinced, but a question of time. When the day comes—and every day brings us nearer to it—when steel will be manufactured as cheaply as iron, then will wrought-iron be a thing of the past among the great civilized nations.

One word as regards the employment of steel made by these modern methods for cutlery. Cutlery-manufacturers would tell you that it is useless for the purpose; nevertheless, on the Continent, it is very largely used, and in this country to a considerable extent. I do not hesitate to assert that, with suitable ores and proper care in the manufacture, steel well suited for cutlery can be made both in the open-hearth and the converter. The essential in the ore is that it should not contain phosphorus; with but a trace of phosphorus present, a good cutting edge could never be obtained.

If we glance back for a moment to review our history, we shall see that the open-hearth processes embody the same principle as the first process by which steel was produced, viz., the mutual action of carburized iron and oxide of iron on one another, and the Bessemer process is, after all, though a splendid offspring, only the natural descendant of the finery process, the origin of which, as we have seen, was due to modifications in the primitive blast-furnaces. There is perfect continuity throughout, and, after all, what more natural?

INTELLIGENCE OF ANTS.

By GEORGE J. ROMANES.

II.

I HAVE now presented some of the most curious and interesting facts concerning the intelligence of ants in general; I shall next proceed to state some of the more remarkable facts concerning the intelligence of certain species of ants in particular.

Leaf-cutting Ants of the Amazon.—The mode of working practiced by these ants is thus described by Bates:

> They mount a tree in multitudes. . . . Each one places itself on the surface of a leaf, and cuts with its sharp, scissors-like jaws a nearly semicircular incision on the upper side; it then takes the edge between its jaws, and by a sharp jerk detaches the piece. Sometimes they let the leaf drop to the ground, where a little heap accumulates, until carried off by another relay of workers; but generally each marches off with the piece it has operated on, and, as all take the same road to the colony, the path they follow becomes in a short time smooth and bare, looking like the impression of a cart-wheel through the herbage.

Other observers have since said that this herbage is regularly felled by the ants in order to make a road. Each ant carries its semicircular piece of leaf upright over its head, so that the home-returning train is rendered very conspicuous. Keener observation shows that this home-returning, or load-carrying, train of workers keeps to one side of the road, while the outgoing, or empty-handed, train keeps to the other side; so that on every road there is a double train of ants going in opposite directions. When the leaves arrive at the nest they are received by a smaller kind of worker, whose duty it is to cut up the pieces into still smaller fragments, whereby the leaves seem to be better fitted for the purpose to which, as we shall presently see, they are put. These smaller workers never take any part in the out-door labor; but they occasionally leave the nest, apparently for the sole purpose of obtaining air and exercise, for when they leave the nest they merely run about doing nothing, and frequently, as in mere sport, mount some of the semicircular pieces of leaf which the carrier-ants are taking to the nest, and so get a ride home.

From his continued observation of these ants Bates concludes—and his opinion has been corroborated by that both of Belt and Müller—that the object of all this labor is a highly remarkable one. The leaves when gathered do not themselves appear to be of any service to the ants as food; but, when cut into small fragments and stored away in the nests, they become suited as a nidus for the growth of a minute kind of fungus on which the ants feed. We may therefore call these insects "gardening ants," inasmuch as all their labor is given to the rearing of nutritious vegetables on artificially prepared soil. They are

not particular as to the material which they collect and store up for soil, provided that it is a material on which the fungus will grow —orange-peel, certain flowers, etc., being equally acceptable to them. But they are very particular regarding the ventilation of their underground storehouses, on a suitable degree of which the successful growth of the fungus presumably depends. They therefore have numerous holes or ventilating shafts which lead up to the surface from the storehouses or underground gardens, and these they either open or close according to the horticultural requirements as regards temperature and moisture. If the leaves are either too damp or too dry, they will not grow the fungus, and therefore in gathering the leaves the ants are very particular that they should neither be the one nor the other. Thus Bates observed :

> If a sudden shower should come on, the ants do not carry the wet pieces into the burrows, but throw them down near the entrances; should the weather clear up again, these pieces are picked up when nearly dried and taken inside; should the rain, however, continue, they get sodden down into the ground, and are left there. On the contrary, in dry and hot weather, when the leaves would get dried up before they could be conveyed to the nest, the ants, when in exposed situations, do not go out at all during the hot hours, but bring in their leafy burdens in the cool of the day and during the night.

Dr. Ellendorf made the experiment of interrupting the advance of a column of these ants, with the interesting result which he thus describes in a letter to Büchner :

> Thick dry grass stood on either side of their narrow road, so that they could not pass through it with the load on their heads. I placed a dry branch, nearly a foot in diameter, obliquely across their path, and pressed it down so tightly on the ground that they could not pass underneath. The first comers crawled beneath the branch as far as they could, and then tried to climb over, but failed owing to the weight on their heads. Meanwhile the unloaded ants from the other side came on, and when these succeeded in climbing over the bough there was such a crush that the unladen ants had to clamber over the laden, and the result was a terrible muddle. I now walked along the train, and found that all the ants with their bannerets on their heads were standing still, thickly pressed together, awaiting the word of command from the front. When I turned back to the obstacle, I was astonished to see that the loads had been laid aside by more than a foot's length of the column, one imitating the other. And now work began on both sides of the branch, and in about half an hour a tunnel was made beneath it. Each ant then took up its burden again, and the march was resumed in the most perfect order.

The operations here described show clearly that these ants act upon the principle of the division of labor. In this connection I may also quote an observation of Belt, which shows this fact in perhaps even a stronger light. He says :

> Between the old burrows and the new one was a steep slope. Instead of descending this with their burdens, they cast them down on the top of the slope,

whence they rolled down to the bottom, where another relay of laborers picked them up and carried them to the new burrow. It was amusing to watch the ants hurrying out with bundles of food, dropping them over the slope, and rushing back immediately for more.

Ants of this genus are very clever at making tunnels. The Rev. H. Clark says that in one case they have made a tunnel of enormous length under the river Parahylia, where this is as broad as the Thames at London—their object being to reach a storehouse which is on the opposite bank. This statement is not to be considered so incredible as it at first sight unquestionably appears, for Bates has seen the subterranean passages of these ants extending to a distance of seventy yards.

Harvesting Ants.—The harvesting ants belong almost exclusively to a single genus, which, however, comprises a number of species distributed in localized areas over all the four quarters of the globe. Their distinctive habits consist in gathering nutritious seeds of grasses during summer, and storing them in granaries for winter consumption. We owe our present knowledge concerning these insects mainly to Moggridge, who studied them in the south of Europe, Lincecum and McCook, who studied them in Texas; Colonel Sykes and Dr. Jerdon also made some observations upon them in India. They likewise occur in Palestine, where they were clearly known to Solomon and other writers of antiquity, whose claim to accurate observation in this matter has within the last few years been amply vindicated, after having been for many years discredited, on account chiefly of the adverse statements of Huber.

Moggridge found that from the nest in various directions there proceed outgoing trains, which may be thirty or more yards in length, and each consisting of a double row of ants moving in opposite directions. Like the leaf-cutting ants, those composing the outgoing train are empty-handed, while those composing the incoming train are laden. But here the burdens are grass-seeds. At their terminations in the foraging-ground, or ant-fields, the insects composing these columns disperse by hundreds among the seed-yielding grasses. They then ascend the stems of the grasses, and, seizing the seed or capsule in their jaws, fix their hind-legs firmly as a pivot, round which they turn and turn till the stalk is twisted off. The ant then descends the stem,

patiently backing and turning upward again as often as the clumsy and disproportionate burden becomes wedged between the thickly-set stalks, and joins the line of its companions to the nest. . . . Two ants sometimes combine their efforts, when one stations itself near the base of the peduncle, and gnaws it at the point of greatest tension, while the other hauls upon it and twists it. . . . I have occasionally seen ants, engaged in cutting the capsules of certain plants, drop them, and allow their companions below to carry them away; and this corresponds with the curious account given by Ælian of the manner in which the spikelets of corn are severed and thrown down "to the people below."

As further evidence that these insects well understand the advantages arising from the division of labor, I may quote one or two other observations. Thus Moggridge once saw a dead grasshopper carried into a nest of harvesting ants by the following means :

> It was too large to pass through the door, so they tried to dismember it. Failing in this, several ants drew the wings and legs as far back as possible, while others gnawed through the muscles where the strain was greatest. They succeeded at last in pulling it in.

Again, Lespis says of the harvesting ant that,

> if the road from the place where they are gathering their harvest to the nest is very long, they make regular depots for their provisions under large leaves, stones, or other suitable places, and let certain workers have the duty of carrying them from depot to depot.

No less, therefore, than the leaf-cutting ants already described, do these harvesting ants appreciate the benefits arising from the division of labor ; and, as we shall presently see, there is a kind of ant exhibiting widely different habits, which shows appreciation of this principle in an even higher degree.

When the grain is taken into their nest by the harvesters, it is stored in regular granaries, but not until it has been denuded of its "husks" or "chaff." The denuding process, which corresponds to thrashing, is carried on below-ground, and the chaff is brought up to the surface, where it is laid in heaps to be blown away by the wind. It is not yet understood why the seed, when thus stored in subterranean chambers just far enough below the surface to favor germination, does not germinate. Moggridge proved that the vitality of the seeds is not impaired, for he grew some plants from seeds taken from the granaries ; and he also found that the seeds would germinate even in the granaries, if the ants were prevented from obtaining access to them for two or three days. The non-germination of the seeds must, therefore, be due to some influence exerted by the ants. Moggridge thought this influence might be the exhalations from the ants, and so tried inclosing some seeds in a bottled test-tube, containing also earth and ants. The seeds, however, sprouted ; and even an atmosphere of formic-acid vapor was found not to prevent germination. Probably, therefore, the ants in their granaries do something to the seeds for the express purpose of preventing germination ; and, if so, it would be interesting to botanists to ascertain what this process can be.

But, be this as it may, there is no doubt that the ants are fully aware of the importance in this connection of keeping their garnered seeds as dry as possible ; for when the latter prove over-moist after collection, or have been subsequently wetted by soaking rains, the insects bring them up to the surface and spread them out to dry, to be again brought into the nest after a sufficient exposure.

Lastly, Moggridge observed that the process, whatever it is, where-

by the ants prevent germination, is not invariably successful, but that a small percentage of stored seeds sometimes do begin to germinate. When this was the case, he also observed the highly interesting fact that the ants then knew the most effective method of checking further germination, for he found that in these cases they gnawed off the tip of the sprouting radicle. This fact deserves to be considered as one of the most remarkable among the many remarkable facts of ant psychology.

Passing on now to the harvesting ants of the New World, the insects here remove all the herbage above their nest in the form of a perfect circle, or "disk," fifteen to twenty feet in diameter. Every grass or weed within the disk is carefully felled, and, as the nests are situated in thickly-grown localities, the effect of the bald or shaven disk is highly conspicuous and peculiar, exactly resembling in miniature the "clearings" which are made by settlers in the backwoods. The disk, however, is not merely cleared of herbage, but also carefully leveled—all inequalities of the surface being reduced by pellets of soil being built into the hollows to an extent sufficient to make a uniformly flat surface. In the center of the disk is the gateway of the nest. From the disk in various directions there radiate out-roads or avenues, which are cleared and smoothed like the disk. These roads course through the thick grass, branching and narrowing as they go, till they eventually taper away. They are usually four to seven inches wide at their origin, and may be from sixty to three hundred feet in length. Along these roads there is always passing during the daytime a constant double stream of ants, one being laden and the other not.

In their manner of gathering and garnering grain these harvesters resemble in general the harvesters of Europe; but it is alleged by Dr. Lincecum that in one respect their habits manifest an astonishing, and indeed wellnigh incredible, advance upon those of their European allies. For this observer, who, it must be remembered, was the first to call attention to these ants in the New World, and whose other observations, extending over a number of years, have since been fully confirmed—this observer states in the most positive terms that the ants actually sow the seeds of a certain plant called the ant-rice, for the purpose of subsequently reaping a harvest of grain; hence these ants have been called the "agricultural ants." Now, there is no doubt, from the subsequent observations of McCook and others, that the ant-disks do very frequently support this peculiar kind of grass, and that the ants are particularly fond of its seed. Nevertheless, McCook did not himself witness the process of sowing, although he is not disposed to doubt the statements of his predecessor upon the subject. These statements, as already observed, are most emphatic and precise—Lincecum saying, in italics, that he knows and is certain about the fact; but until corroborated it is safest to regard the fact as not yet fully established.

Honey-making Ants.—These ants are found in Texas and New Mexico. Their remarkable habits have been observed by Captain Fleeson, who communicated his observations to Mr. Darwin.

The community consists of three distinct kinds of ants, which appear to belong to two distinct genera. These are:

I. Yellow workers; nursers and feeders of II.

II. Yellow honey-makers; sole function to secrete a kind of honey in their large globose abdomens, on which the other ants are supposed to feed. They never quit the nest, and are fed and tended by I.

III. Black workers; guards and purveyors, which surround the nest as sentinels, and also forage for the food required for I. They are much larger and stronger than either I or II, and are provided with very formidable mandibles.

The nest is in the form of an absolutely perfect square, of which each side measures from four to five feet, and the surface of which is kept quite unbroken save at two points, at each of which there is a very minute hole or entrance. One of these minute holes occurs near the west side of the square, and the other near the southeast corner; for it must be remarked that the square is always built with precise reference to the points of the compass, in such a way that one side faces due north, and consequently the others due south, east, and west. These boundaries are rendered very conspicuous by the guard of black workers or soldiers (III), which continuously parade round three of the sides in a close double line of defense, moving in opposite directions. This sentry-path occupies the north, east, and west boundaries, the south side of the square being left open; but, if an enemy approaches on this or any other side, a number of the guards leave their stations and sally forth to face the foe, raising themselves on their hind-legs on meeting the enemy, and moving their large mandibles in defiance. After tearing the enemy to pieces the guards return to their places in the line of defense, their object in destroying any insect or other small intruders being defense of the encampment, and not the obtaining of food.

The southern side of the square encampment, or rather fortress, is left open as just described in order to admit of a free entry of supplies. While some of the black workers are on duty as gurad, another and larger division are engaged on duty as purveyors. These enter and leave the quadrangle by its southwest corner in a double line (one laden and the other not), which follows exactly the diagonal of the square to its central point, where all the booty, consisting of flowers and aromatic leaves, is deposited in a heap. Passing from this central heap to the entrance at the southeast corner of the quadrangle, and therefore occupying the other semi-diagonal of the square, there is another double line of workers constantly engaged in carrying the booty from the central deposit into the storehouses below-ground. These workers are exclusively composed of Class II, whose whole life

is therefore spent in running backward and forward upon this semi-diagonal of the square, carrying in food and feeding Class I. No black ant is ever seen on the eastern diagonal, and no yellow ant is ever seen on the western; but each keeps to his own separate station, and here works with a steadfastness and apparent adherence to discipline which are not less remarkable than those exhibited by the sentries. The western hole before mentioned seems to be intended only as a ventilating shaft; it is never used as a gateway.

Section of the nest reveals, besides passages and galleries, a small chamber, across which is spread, like a spider's web, a network of squares spun by the insects. In each of these squares, supported by the web, sits one of the honey-secreting ants (II). Here the honey-makers live in perpetual confinement, and receive a constant supply of flowers, pollen, etc., which is continually being brought them by I, and which, by a process of digestion and secretion, they convert into honey. It is particularly noteworthy that in this truly wonderful exhibition of social coöperation the black and yellow workers appear to belong to two distinct genera; for hitherto this is the only case known of two distinct species of animals coöperating for a common end.

Ecitons.—We have lastly to consider the most astonishing insects, if not the most astonishing animals, in the world. These are the so-called "foraging," or, as they might more appropriately be called, the military ants of the Amazon. They belong to several species of the same genus, and have been carefully watched by Bates, Belt, and other naturalists. The following facts must therefore be regarded as fully established:

Eciton legionis moves in enormous armies, and everything that these insects do is done with the most perfect instinct of military organization. The army marches in the form of a rather broad and regular column, hundreds of yards in length. The object of the march is to capture and plunder other insects, etc., for food, and, as the well-organized host advances, its devastating legions set all other terrestrial life at defiance. From the main column there are sent out smaller lateral columns, the composing individuals of which play the part of scouts, branching off in various directions, and searching about with the utmost activity for insects, grubs, etc., over every log and under every fallen leaf. If prey is found in sufficiently small quantities for them to manage alone, it is immediately seized and carried to the main column, but, if the amount is too large for the scouts themselves to deal with, messengers are sent back to the main column, whence there is immediately dispatched a detachment large enough to cope with the requirements. Insects or other prey which, when killed, are too large for single ants to carry, are torn in pieces, and the pieces conveyed back to the main army by different individuals. Many insects in trying to escape run up bushes and shrubs, where they are

pursued from branch to branch and twig to twig by their remorseless enemies, till, on arriving at some terminal ramification, they must either submit to immediate capture by their pursuers or drop down amid the murderous hosts beneath. As already stated, all the spoils which are taken by the scouts, or by the detachments sent out in answer to their demands for assistance, are immediately taken back to the main army or column. When they arrive there, they are conveyed to the rear of that column by two smaller columns of carriers, which are constantly running in two double rows (one of each being laden and the other not) on either side of the main column. On either side of the main column there are also constantly running up and down a few individuals of smaller size, lighter color, and having larger heads than the other ants. These appear to perform the duty of officers, for they never leave their stations, and, while actively running up and down the outsides of the column, they seem intent only on maintaining order in the march—stopping every now and then to touch some member of the rank and file with their antennæ, as if giving directions.

When the scouts discover a wasp's nest in a tree, a strong force is sent out from the main army, the nest is pulled to pieces, and all the larvæ in the nest are carried by the carrier-columns to the rear of the army, while the wasps fly around defenseless against the invading multitudes. Or, if the nest of any other species of ant is found, a similarly strong force is sent out, or even the whole army may be deflected toward it, when with the utmost energy the innumerable insects set to work to sink shafts and dig mines till the whole nest is rifled of its contents. In these mining operations the Ecitons work with an extraordinary display of organized coöperation; for those low down in the shafts do not lose time by carrying up the earth which they excavate, but pass on the pellets to those above, and the ants on the surface, when they receive the pellets, carry them only just far enough to insure that they shall not roll back again into the shaft, and, after having deposited them at a safe distance, immediately hurry back for more.

The Ecitons have no fixed nest themselves, but live, as it were, on a perpetual campaign. At night, however, they call a halt and pitch a camp. For this purpose they usually select a piece of broken ground, in the interstices of which they temporarily store their plunder. In the morning the army is again on the march, and before an hour or two has passed not a single ant is to be seen where thousands and millions had previously covered the ground.

The habits of *E. humana* and *E. drepanophora* are in general similar to those of the species just described. The latter, however, march in a narrower column (only four to six deep), which is therefore proportionally longer—sometimes extending to over half a mile. Bates tried the effect of interfering with a column of this species by

abstracting an individual from it. "News of the disturbance was quickly communicated to a distance of several yards to the rear, and the column at that point commenced retreating." It was also this species that the same naturalist describes as enjoying periods of leisure and recreation when they call a halt in "the sunny nooks of the forest." On such occasions,

the main column of the army and the branch columns were in their ordinary relative positions; but, instead of pressing forward eagerly and plundering right and left, they seemed to have been all smitten with a sudden fit of laziness. Some were walking slowly about, others were brushing their antennæ with their forefeet; but the drollest sight was their cleaning each other. . . . It is probable that these hours of relaxation and cleansing may be indispensable to the effective performance of their harder burdens; but, while looking at them, the conclusion that they were engaged merely in play was irresistible.

E. prædator differs from the others of its genus in not hunting in columns, but "in dense phalanxes consisting of myriads of individuals."

Nothing (says Bates) in insect movements is more striking than the rapid march of these large and compact bodies. Wherever they pass, all the rest of the animal world is thrown into a state of alarm. They stream along the ground and climb to the summit of all the lower trees, searching every leaf to its apex, and, whenever they encounter a mass of decaying vegetable matter where booty is plentiful, they concentrate, like other Ecitons, all their forces upon it, the dense phalanx of shining and quickly-moving bodies, as it spreads over the surface, looking like a flood of dark-red liquid. They soon penetrate every part of the confused heap, and then, gathering together again in marching order, onward they move.

A phalanx occupies from four to six square yards of ground, and the ants composing it do not move "altogether in one straightforward direction, but in variously spreading contiguous columns, now separating a little from the general mass, now reuniting with it. The margins of the phalanx spread out at times like a cloud of skirmishers from the flanks of the main army."

Two species of Eciton are totally blind, and the habits of these differ from those above described in that they march exclusively under covered roads or tunnels. The van of the column is constantly engaged in rapidly constructing the tunnels through which the army or regiment advances as quickly as they are made. Under the protection of these covered ways the ants travel at a surprising rate, and, when they reach a rotten log or other promising hunting-ground, they pour into all the crevices, etc., in search of prey. Bates says:

The blind Ecitons, working in numbers, build up simultaneously the sides of their convex arcades, and contrive, in a wonderful manner, to approximate them and fit in the key-stones without letting the loose, uncemented structure fall to pieces. There was a very clear division of labor between the two classes of neuters in these blind species. The large-headed class . . . act as soldiers,

defending the working community (like soldier termites) against all comers. Whenever I made a breach in one of their covered ways, all the ants underneath were set in commotion, but the worker-miners remained behind to repair the damage, while the large-heads issued forth in a most menacing manner.

These two blind species of Eciton are particularly interesting from the fact that in a part of the world so remote from them as Western Africa there is another genus of military ant, also blind, which in all its habits closely resembles the blind Ecitons of Brazil. For, like the latter, *Annornia arcens* march in long, close columns through tunnels, have no fixed nest, but make temporary halts in shaded places, and are no less organized, remorseless, and irresistible than their American congeners. In one curious particular, however, they differ: the relative position of the marchers and the carriers is reversed, for here the carrier-columns occupy the middle place, while the marching columns with their officers occupy the flanks. When overtaken by a sudden African rain-storm, these ants congregate in a close mass, with the younger ants in the center; they thus form a floating island.

It is remarkable that ants of different hemispheres should manifest so close a similarity with respect to all these wonderful habits. The Chasseur ants of Trinidad, and, according to Madame Merian, the ants of Visitation of Cayenne, also display habits of the same kind.

Special Instances of the Display of High Intelligence.—I shall conclude this brief *résumé* of the more important facts at present known concerning the psychology of ants with a few selected observations of the display of high intelligence. It is always difficult to draw the line between instinct and reason, between adjustive action due to hereditary or purposeless habit and adjustive action due to individual and purposive adaptation. But we may be least diffident in accepting as evidence of the latter cases where animals exhibit a power of adapting their actions to meet the requirements of novel circumstances—or circumstances which can not be supposed to have been of sufficiently frequent occurrence in the life-history of the species to have developed instincts of mechanical response in the individual. It is in view of this consideration that the following instances are selected.

Ebrard records in his "Études de Mœurs" an observation of his own on *F. fusca*. The ants were engaged in building walls, and when the work was nearly completed there still remained an interspace of twelve or fifteen millimetres to be covered in. For a moment the ants were thrown out, and

seemed inclined to leave their work, but soon turned instead to a grass-plant growing near, the long, narrow leaves of which ran close together. They chose the nearest, and weighted its distal end with damp earth, until its apex just bent down to the space to be covered. Unfortunately, the bend was too close to the extremity, and it threatened to break. To prevent this misfortune the ants gnawed at the base of the leaf until it bent along its whole length and covered the space required. But, as this did not seem to be quite enough, they heaped

damp earth between the base of the plant and that of the leaf, until the latter was sufficiently bent. After they had attained their object, they heaped on the buttressing-leaf the materials required for building the arched roof.

This observation naturally leads to two others by two different observers. Thus, Moggridge says: "I was able to watch the operation of removing roots which had pierced through their galleries, belonging to seedling plants growing on the surface, and which was performed by two ants, one pulling at the free end of the root, and the other gnawing at its fibers where the strain was greatest, until at length it gave way." Again, as previously quoted in another connection, he says that two ants sometimes combine their efforts, one stationing itself near the base of a footstalk and gnawing at the point of greatest tension, while the other hauls upon and twists it.

The other observer to whom I have referred is McCook, who says of the harvesting ants of America that he has seen "the workers, in several cases, leave the point at which they had begun a cutting, ascend the blade, and pass as far toward the point as possible. The blade was thus borne downward, and, as the ant swayed up and down, it really seemed that she was taking advantage of the leverage thus gained, and was bringing the augmented force to bear upon the fracture. In two or three cases there appeared to be a division of labor; that is to say, while the cutter at the roots kept on with his work, another ant climbed the grass-blade and applied the power at the opposite end of the lever. This position may have been quite accidental, but it certainly had the appearance of voluntary coöperation."

These observations serve to render less improbable the following quotation taken from Bingley's account of Captain Cook's expedition in New South Wales, and vouched for by Sir J. Banks. Green ants were seen forming their nests in trees by "bending down several of the leaves, each of which is as broad as a man's hand, and gluing the points of them together so as to form a purse. . . . We saw thousands uniting all their strength to hold them in this position, while other busy multitudes within were employed in applying the gluten that was to prevent their returning back."

Moggridge says that he has seen the harvesting ants of Europe clustering round the larva of a certain beetle, and directing it toward some small opening in the soil, "which it would quickly enlarge and disappear down"; and he believes that "these attentions were purely selfish," the ants availing "themselves of the tunnel thus made down into the soil."

McCook says of the harvesters of America that they dislike shade, so that if a tree grows up in their vicinity and casts a shadow over their nest they forthwith migrate. He gives in this connection a statement which I regard as bordering on the incredible, and therefore I desire it to be specially observed that it is not very evident from

McCook's account whether he himself witnessed the facts. The facts, however, which he narrates, are that a peach-tree having grown up so as to overshadow a nest of harvesting ants, the latter climbed the tree to strip off the leaves. "I am convinced," says McCook, "that the reason for this onslaught was the desire to be rid of the obnoxious shade." If this statement had been met with in any ordinary book on animal intelligence, of course I should not have quoted it; but as McCook went to Texas for the express purpose of studying these ants in a scientific manner, and as the numerous other observations which he made, both on these and on the mound-building species, entitle him to respect, I have not felt justified in suppressing this statement.

The observation made by Colonel Sykes on certain ants in India has gained a wide notoriety from its having been published by Spence in his popular work on instinct. Colonel Sykes was a good observer, so that his account ought not to be questioned. He says that in order to guard his provisions from the ants he put them on a table, the four legs of which he placed in as many basins filled with water. Some ants still succeeded in scrambling across the water, and so the legs of the table were likewise painted with turpentine. The ants then ran up a wall near which the table stood, and when about a foot above its level, they sprang from the wall to the table.

Somewhat analogous to this is the observation of Professor Leuckhart, who placed round the trunk of a tree, which had been visited by ants as a pasture for aphides, a broad cloth soaked in tobacco-water. When the ants, returning home down the trunk of the tree, arrived at the soaked cloth, they turned round, went up the tree again to some of the overhanging branches, and allowed themselves to drop clear of the obnoxious barrier. On the other hand, the ants which desired to mount the tree first examined the nature of the obstruction, then turned back and procured some pellets of earth, which they carried in their jaws and deposited, one after another, upon the cloth till a harmless road of earth was made across it.

This observation of Professor Leuckhart is in turn a corroboration of an almost identical one made more than a century ago by Cardinal Fleury, and communicated by him to Réaumur, who published it in his "Natural History of Insects" (1734). The Cardinal smeared the trunk of a tree with bird-lime, in order to prevent the ants from ascending it; but the insects overcame the obstacle by making a road of earth, small stones, etc., as in the case just mentioned. On another occasion the Cardinal saw a number of ants make a bridge across a vessel of water surrounding the bottom of an orange-tree tub. They did so by conveying a number of little pieces of *wood*, the choice of that material, instead of earth or stones, as in the previous case, apparently betokening no small knowledge of practical engineering—a knowledge which, as we shall presently see, is also shared by the Ecitons.

Büchner, in his recently published and translated work on "Mind in Animals," gives a singular observation analogous to the above, which was communicated to him by Herr G. Theuerkauf. A maple-tree standing in the grounds of Herr Vollbaum, of Elbing, swarmed with ants and aphides. In order to check the mischief, the proprietor smeared about a foot width of the ground around the tree with tar. The first ants that arrived stuck fast; but the next, seeing the predicament of their companions, turned back and fetched a number of aphides from the tree, which they stuck down on the tar one after another till they had made a bridge over which they could cross without danger.

It will be observed that all these cases, being so analogous although recorded independently by different observers, serve to corroborate one another. As such corroboration in matters of this kind is of value, I shall here add two or three cases which go to confirm the observation of Cardinal Fleury regarding the construction of a floating bridge. Dr. Ellendorf writes to Professor Büchner that he protected a cupboard of his provisions from the invasion of ants by standing the legs of the cupboard in saucers filled with water. He adds:

> I myself did this, but I none the less found thousands of ants in the cupboard next morning. It was a puzzle to me how they crossed the water, but the puzzle was soon solved. For I found a straw in one of the saucers. . . . This they had used as a bridge. . . . I pushed the straw about an inch from the cupboard-leg, when a terrible confusion arose. In a moment the leg immediately over the water was covered with hundreds of ants feeling for the bridge in every direction with their antennæ, running back again and coming in ever larger swarms, as though they had communicated to their companions within the cupboard the fearful misfortune that had taken place. Meanwhile the new-comers continued to run along the straw, and, not finding the leg of the cupboard, the greatest perplexity arose. They hurried along the edge of the saucer, and soon found where the fault lay. With united forces they pulled and pushed at the straw, until it again came into contact with the wood, and the communication was again restored.

The military ants, both in America and Africa, exhibit still more extraordinary resources in the way of bridge-making. Thus Belt says of the Ecitons:

> I once saw a wide column trying to pass along a crumbling, nearly perpendicular, slope. They would have got very slowly over it, and many of them would have fallen; but a number having secured their hold, and reaching to each other, remained stationary, and over them the main column passed. Another time they were crossing a water-course along a small branch, not thicker than a goose-quill. They widened this natural bridge to three times its width by a number of ants clinging to it and to each other on each side, over which the column passed three or four deep; whereas, excepting for this expedient, they would have had to pass over in single file, and treble the time would have been consumed.

It is remarkable that the military or driving ants of Africa exhibit precisely similar devices for the bridging of streams as the Ecitons of America, namely, by forming a chain of individuals over which the others pass. By means of similar chains they also let themselves down from trees.

But of the Ecitons another and more recent observer gives an account of a yet more remarkable device, although no doubt a development of the one just described. This observer is Herr H. Kreplin, who lived for nearly twenty years in South America as an engineer, and often had the opportunity of watching the Ecitons. He writes to Büchner under date 1876 as follows:

> If the water-course be narrow, the thick-heads (officers) soon find trees, the branches of which meet on the bank of either side, and after a short halt the columns set themselves in motion over these bridges, rearranging themselves in a narrow train with marvelous quickness on reaching the farther side. But, if no natural bridge be available for the passage, they travel along the bank of the river until they arrive at a flat, sandy shore. Each ant now seizes a bit of dry wood, pulls it into the water and mounts thereon. The hinder rows push the front ones ever farther out, holding on to the wood with their feet and to their comrades with their jaws. In a short time the water is covered with ants, and when the raft has grown too large to be held together by the small creatures' strength, a part breaks off and begins the journey across, while the ants left on the bank busily pull their bits of wood into the water and work at enlarging the ferry-boat until it again breaks. This is repeated as long as an ant remains on shore.

I shall now bring these numerous instances to a close with a quotation from Belt, which reveals in a most unequivocal manner astonishing powers of observation and reason in the leaf-cutting ants of South America, the general habits of which we have already considered:

> A nest was made near one of our tramways, and to get to the trees the ants had to cross the rails, over which the wagons were continually passing and repassing. Every time they came along a number of ants were crushed to death. They persevered in crossing for some time, but at last set to work and tunneled underneath each rail. One day, when the wagons were not running, I stopped up the tunnels with stones; but although great numbers carrying leaves were thus cut off from the nest, they would not cross the rails, but set to work making fresh tunnels beneath them.

Such, then, are some of the more well-established facts regarding the intelligence of ants, and taken altogether they certainly seem to justify the remark of the most illustrious of naturalists, "The brain of an ant is one of the most marvelous atoms of matter in the world, perhaps more so than the brain of a man."—*Nineteenth Century.*

FOREST-CULTURE IN ALPINE RAVINES.*

By M. J. CLEVE.

WHATEVER differences of opinion may exist respecting the meteorological influence of forests, it is generally agreed that in mountainous countries they play an important part in regulating water-courses and in preserving the soil on the slopes of the hills. This function, which has been observed for a long time, was presented in a clear light by M. Surrell, engineer of bridges and highways, whose fine work on the torrents of the high Alps ("Torrens des Hautes-Alps"), published in 1841, has been the point of departure for all studies and all legal projects respecting rewooding. While the author had in view only the restoration of the French Alps, his conclusions are applicable, although in different degrees, to all mountainous countries; but the phenomena which he considers are manifested with the most intensity in the Alps, and the renewal of the woods there is imposed as a real measure of public policy.

In respect to vegetation, nature has divided the Alpestrian mountains into three zones: creating on the summits, around the rocks and glaciers, pasture-lands; on the middle slopes, forests; in the lower valleys, lands suited to occupation by agriculture and by villages. Unfortunately, this natural division has been too often disturbed; the inhabitants, leaving the valleys, have established themselves in the higher regions, have cut down the forests around their houses, and devoted to cultivation lands which, disintegrated by the plow, are incessantly cut up into ravines by every rain; or the zone of pasture-lands has encroached on that of the forests, and has been increased by the daily devastations of the shepherds. Extending its borders every year lower down the mountain, it has finished by taking possession of the slopes and despoiling them of their wood. Gradually the grass itself, no longer protected by the cover of large trees and continually fed upon by hungry flocks, has disappeared, leaving behind it only the denuded flank of the mountain, an easy prey of which the torrents have not been slow to take possession.

The mountain-torrent is not an ordinary brook, but is a stream with characters of its own and peculiar ways. Originating in a narrow basin, the bed of which is very steep, it is subject to sudden variations;

* [Some instructive reports have recently been published in France concerning the progress that has been made in rewooding the slopes of the Alps, which, having been stripped of trees, are most exposed to the ravages of torrents. While the Alps present features which have no counterpart in the settled regions in the United States, the problems which had to be solved in reclothing the lower parts of the mountains with wood and staying the processes of devastation involve principles which may be applied as well in our own hilly and mountainous districts.—Editor.]

often wholly dry, it becomes a flood after a storm, and overcomes all the obstacles that oppose its course. There are clear torrents and muddy torrents. The former, which are the torrents of eruptive regions, carry but little matter with them, and are characterized by sudden freshets, which are due to the fact that the waters running over impermeable rocks, are precipitated immediately into the ravines and collect in considerable masses. The torrents of the second class have formed themselves beds in the loose soil, are continually washing away the bases of their banks, provoking slides, carrying with them solid matters derived from the degradation of the hills, and discharging them in the lower valleys and covering the fields with a thick mud. The bed of the torrent is washed out more and more, and the banks increase at the same time; new ravines are formed, and branches of them, thus eating away the spur of the mountain, which is gradually destroyed, or which, undermined at the base, occasionally slides bodily into the valley, which it closes up.

Attention has long been given to devising means to limit the ravages of these torrents, which ruin the land, threaten estates, destroy roads, and sometimes even compromise the existence of villages. Walls have been built along the banks to protect them, or across the streams to allay the force of the waters. The most efficacious means, however, as yet discovered, has been to maintain the woods on the slopes of the mountain. The effect of cutting away the trees in promoting the formation of torrents has not been doubted by the inhabitants of mountainous regions, and is clearly set forth by M. Surrell, who says: "When we examine the tracts in the midst of which torrents of recent origin have been formed, we perceive that they have in all cases been despoiled of their trees and bushes. If, on the other hand, we examine hills whose sides have been recently stripped of wood, we observe that they are cut up by numerous torrents, which have evidently been formed very lately. Here is a remarkable double fact: wherever there are recent torrents there are no longer forests, and wherever the ground is cleared these torrents are formed; and the same eyes that see the woods fall on the declivity of a mountain, may see appear there immediately a multitude of torrents."

The disastrous consequences of removing the woods from the Alps began to attract attention in the last century, and have since been discussed in many publications and official reports. In 1853 the prefect of the department of the Lower Alps said in a report to the Minister: "If prompt and energetic measures are not taken, it will be almost possible to designate the precise moment when the French Alps will become a desert. The period from 1851 to 1853 will produce a new diminution in the number of the population. In 1862 the Minister will remark a continuous and progressive reduction in the number of hectares devoted to agriculture; each year will aggravate the evil, and in a half-century France will count more ruins and one depart-

ment less." The departments of the Upper and Lower Alps actually lost thirty thousand inhabitants, or one ninth of their population, between 1851 and 1876. A law for recovering the mountains with wood, which had been prepared by M. Forçade de Rouguet, director-general of the administration of the forests, was adopted by the legislative bodies in 1860, and was put in operation shortly afterward.

In some cases, the work of planting woods is left optional, but is encouraged by the offer of rewards to the communes or individuals who undertake it. In other cases, where the public interest is at stake, the state determines the area of land to be planted, and allows the proprietors to perform the work if they will; if they refuse to do so, it attends to the matter itself, taking care that its proceedings shall be as inoffensive to the people as they can be made, and be at the same time effective.

The first question that is presented in dealing with a hill that has been cut up with ravines is to determine the perimeter of the lands to be restored. The area should not be limited to the banks of the torrent and its branches, for these banks, being continually undermined and always changing, would continue, by giving way, to enlarge the basin if they were not themselves fixed by vegetation. The justice of the rules which M. Surrell laid down on this point in 1841 has been confirmed by experience. We should begin, he said, to trace along either bank of the torrent a continuous line which shall pursue all the inflections of its course, from its remote origin till it issues from the gorge upon the lower valley. The tract included between each of these lines and the crest of the banks would form what I would call a zone of defense. The zones of the two banks would meet at the upper end, following the contour of the basin, and would thus surround the torrent, like a belt, in its whole extent. Their width, which should vary with the degree of the slope and the consistency of the soil, may be as little as fifty yards at the lower end, but should increase rapidly as the zone rises up the mountain, and should end by including spaces of five or six hundred yards. This delineation is applicable not only to the principal branch of the torrent, but also to the secondary torrents that empty into it, and to the smaller ravines departing from each of these torrents, and thus, pursuing one branch after another, should not stop till it reaches the source of the most remote rill. As these zones of defense go on enlarging up the mountain, they will join, and even merge into each other toward the summit, so as to form a continuous band around the upper part, leaving no void in it.

The perimeter of the land to be rewooded having been determined, the next step is to prohibit pasturage, in order to prevent further disintegration of the soil by the feet of the sheep, and allow the grass to recover. The ultimate result is assisted by cutting the bushes down to the stump, and planting willow-cuttings in horizontal rows about two yards apart, to hold the earth on the almost vertical slopes, and

then sowing the seeds of grasses in the intervals. Concurrently with these preliminary operations, the only object of which is to prepare the soil for the reception of the forest-growth to be planted later, the torrent itself is attacked with works intended to impede its course, hold back the drift-matter, and prevent further undermining of the banks. For this purpose wattles and bars are inserted along the stream and its smallest ramifications, beginning generally at the upper parts, where the water, not having acquired its full force, can be more easily stopped, and the suspended matter may be more easily retained. Green branches of willow and hazel are woven around stakes in the ravine, take root in the soil, and become a living obstacle which perpetuates itself. If the wattles are close enough together, they will transform the ravine into a kind of staircase, by the agency of which the violence of the water is allayed at each step, its force is lessened so that it does not wear upon the soil, and it is made to run almost clear.

More energetic measures are required lower down, where the torrent exercises a more destructive action. Here dams of masonry are inserted in the banks, provided with an arched channel in the lower part to permit the outflow of water at moderate stages of the stream; they serve to hold back the stones that are worked out from the mountain, to promote the growth of alluvions, to break the fall of the torrent and diminish its violence by enlarging its bed. Some of these dams are real works of constructive art, and have cost as much as eight or ten thousand dollars.

The real replanting of the woods is done after the ground has become settled and the torrent has been subdued. Nurseries of young trees suitable for the purpose are previously established near the locality of the works, which are drawn upon as the plants are needed. The species vary according to the nature of the situation and the soil. Generally pines and firs of different kinds are best adapted to the higher situations, deciduous trees to the lower ones. Use has also been made of several species of shrubs and bushes, which with their branching roots are wonderfully fitted to fix the earth, and by reason of their rapid growth quickly furnish a shade to the bare surface. The planting is begun at the top of the elevation and is conducted downward, in such a manner as to leave no places vacant. The young trees, protected against the sun by the grasses which were previously sown and by the willow-cuttings which have already taken root, soon begin to grow with vigor. An effort was made, in accordance with the law of 1864, to substitute regrassing for replanting with wood in the interior of the perimeters; but it did not answer the purpose of consolidating the soil, and was abandoned. Sometimes the communes have shown themselves hostile to the execution of these works on account of the interdiction of pasturage. Such was the case in the communes of Orres and Saint-Sauveur, whose inhabitants drove away the workmen in 1864. The work was resumed three

years afterward, after it had been completed in an adjoining commune, and the people were conciliated by being employed in it. The upper valley of the torrent of Vachères, which was formerly considered one of the largest and most violent torrents of the Alps, once all cut up into ravines, is now covered with vegetation, and the torrent itself is described as extinct; once the terror of the country, it has been changed, at an expense of twenty-four thousand dollars, into an inoffensive river.

Like results have been obtained wherever works of the kind have been executed. M. Gentil, an engineer, reports of one district: "The aspect of the mountain has been changed all at once. The soil has acquired such stability that the violent storms of 1868, which caused great disasters in the high Alps, fell harmlessly on the regenerated perimeters. The mountain has at the same time become productive; where a few sheep could hardly live by destroying everything, may now be seen abundance of grass fit to mow. This method of improvement is remarkable for giving the people what they need most, and for giving it to them with only a brief delay. The pastoral inhabitants find food for their flocks in the grasses and hay of the planted areas and in the foliage of the trees; and the acacias that have been caused to grow there will soon furnish them the wood they will need in their vineyards. The torrential character of the stream has disappeared; the water is less turbid, even in time of rain, and is better adapted to purposes of irrigation. It is no longer loaded with solid matter when it reaches the lower valleys, and naturally keeps its bed. . . . Diversions from the regular course are less liable to occur and less dangerous, and the people on its banks can protect themselves with slight expense." M. Gentil relates several examples of torrents formerly very dangerous which have been fully and permanently subdued by means of such works as have been here described, giving protection to highways that were often interrupted before, and security to valleys that were often in danger, and adds: "Immense benefits have accrued to the lands situated in the lower valleys near the discharging basins of the streams. Not only are the inhabitants delivered from the expense of keeping up costly and precarious dikes; their property, also, being no longer in danger of being suddenly buried under a flood of gravel, has acquired a fixed value. They are able to till their land hopefully, and with the assurance that they will enjoy the crop. This certainty is a blessing of enormous value. The proprietor, able to rely upon the future, will no longer think of leaving the country."

So far as the work of restoration has been executed, its success—in respect to the processes employed and the results obtained—has been complete. The chief question concerning it which remains is as to the extent to which it shall be systematically carried out.—*Revue des Deux Mondes.*

CATTLE-RAISING IN SOUTH AMERICA.

By M. COUTY,

PROFESSOR IN THE POLYTECHNIC SCHOOL OF RIO JANEIRO.*

CATTLE-RAISING is far from having attained a sufficient importance in Brazil. Immense provinces, like those of Goyaz and Matto-Grosso, vast regions from the Amazon to the Parana, where cattle could be raised easily and without care, remain unutilized for want of a market and of convenient means of transport and conservation. There exist, however, some important stock-raising tracts and cattle-exchanges.

I have visited the provinces of Parana and Rio Grande and the state of Montevideo, and what I have to say relates only to those regions. Being neither an agriculturist nor a zoötechnist, I have had to limit myself to incomplete observations, and have endeavored to see how those cattle which are described as half wild, and are without any apparent direct relations with man, have been able to adapt themselves in a definite manner to the different conditions of their life.

Nothing can be more interesting than to study those conditions in which cattle live and are propagated without stables and without an assured supply of food; nothing more instructive than to observe how the time of heat, and consequently of births, the proportion of the young, and even their survival, are differently regulated according to the character of the country, in consequence of different physical conditions. Nothing, moreover, can be more curious than to study the habits of these supposed wild cattle, to see them living in isolated societies, possessing real notions of what is belonging to them, and each member of the community keeping his place. These facts are of further importance, because they have served for the empirical basis of the actual conditions, as they will have to serve as the basis of an improved system of breeding. In all these countries the life of the cattle is wholly free. The stock-raiser, or *estancier*, is the owner of a very extensive tract of pasture-land, and he leaves the animals to live upon it, feed themselves, and multiply at their will. The stock, even in the wildest and least populous regions, form small herds of from one hundred to one hundred and fifty head, which are made up of steers, cows, calves, and bulls; but are always composed of the same individuals, and always inhabit the same very limited region of the *campo*, and the animals pass their lives within this region without being confined by any inclosure. The distinctive character of the

* M. Couty was recently charged by the Minister of Agriculture of Brazil to visit the southern part of the empire and the neighboring states for the information of the department. The paper of which the most essential parts are here given embodies the results of his inquiries.

groups is especially curious in the more populous regions, as the southern part of Rio Grande or Montevideo, where herds may be seen almost in contact without mixing, coming together and making themselves up generally without trouble; and they live thus side by side for years without becoming acquainted with each other. Each herd is so coherent that, when one of its members takes fright and runs away, all will follow it. In consequence of this habit, it is very difficult, when cattle are sold, to separate them from the herds and to get them along for the first few leagues. If they are not watched, they will escape, pass by thousands of other animals without noticing them, and join their companions again. They cease, however, to seek to go back after they have been driven to a considerable distance.

The cattle in these herds also propagate in freedom. Traveling in Parana at a time when the pasturage was excellent and the cattle were in good condition, in January, I saw numerous vigorous bulls living as peacefully as could be with the cows.

The care given by man to the cattle enjoying this freedom of life and procreation, although very restricted, is greater than has been represented. A *rodeo,* or gathering of the different herds at a single point, is held at determined periods, both in Parana and the Oriental Republic. The assemblage may take place near the buildings in an *estancia* of moderate size, often in an inclosed space of suitable capacity called the *mangueira.* In extensive estancias having numerous herds, as it would be almost impossible to collect ten or twenty thousand head at a single point, several rodeos are made in different parts of the campo, always at the same points. In other estancias, notably in Parana, one or two grand rodeos a year are made at the mangueira, and several smaller rodeos at less intervals. The task of driving the cattle up to the rodeo is not a hard one. The beasts stagger along, and go in a mass toward the habitual point of gathering, generally with the bulls at their head The assemblies are kept up for a greater or less length of time, and the peons circulate around the herd, shouting so as to accustom the animals to the presence of man, and to the custom of coming up. The rodeo gives an opportunity to judge of the condition of the flocks, when and what proportion of them may be ready for sale; to practice treatment or different operations; to give the stock salt in Parana, and medical attention in other regions; to mark them and castrate them. Each estancia has its particular mark—often several marks; for in many estancias all the children have their share of the cattle, and, as the slaves also are sometimes allowed to own stock, confusion would result if means were not taken to prevent it.

The intervention of man is also illustrated in the efforts at cross-breeding. I was surprised at the manner in which this is attempted in South America. Everybody wants to acclimatize the races of Europe, and to improve the meat and fattening qualities of the stock; and, to this end, thorough-bred bulls (Herefords, and especially Dur-

hams) have been imported at great expense. An owner desiring to improve the stock of an estancia containing twenty thousand head, will procure three or four Durham bulls, and then will be astonished that the desired effect is not more rapidly produced. He ought not to forget that cross-breeding can not succeed between races so different except upon the condition that the new blood is continually renewed. To transplant the most artificial breed, and the one most difficult to maintain, into a dried-up southern campo, is one of the aberrations which a complete ignorance of European breeding and the taste for imitation alone can explain. It is also surprising that hardly anything has been done, in a region where everything is so favorable, to improve from themselves the races which have already become adapted to the medium and been molded by it. Cross-breeding, although it is highly esteemed, has been tried only in a limited number of estancias, and the selection of the best native stock has not been seriously attempted on any of the estates that I have observed. Although backward in respect to selection, the intervention of man has brought about an improvement in a no less important point of view, in the shape of measures to secure a more regular supply of food. In Parana the grass of the campos is burned at the dry season, in September and October of each year, certain parts, bounded by streams or ditches, being reserved to be burned later, so as to secure a succession of pasturage. In this state, as farther south, another equally simple means of preserving the natural food has been much employed. The most moist, least exposed, or best parts of the campo are inclosed, forming *hivernadas*, if the tract is large, *potreiros*, if it is small, for the cattle which are to be fattened. No inclosures large enough for all the stock have been made yet. These means, however, do not create new food, but only utilize that which already exists, and are of no use when a reserve of food is most necessary—that is, after frosty weather, and at the end of long droughts.

Two other measures might be adopted to assure a regular supply of pasturage, but they have hardly been tried. The easier course would be to install regular irrigation. In Parana the country is hilly, and the water-courses are everywhere maintained through the hot seasons. Farther south, it might be possible to irrigate large tracts through the whole year. Estanciers who, like M. Carlos Reyles at Durasno, have instituted irrigation on a considerable scale, have realized increased profits from it. Nevertheless, it is easy to count the breeders who have tried irrigation. There is probably not one in Parana, where, if you suggest it, the breeder will answer that an excess of water will promote the growth of worthless plants. The condition of the cattle might be improved, and the return from them increased, by dividing the enormous droves, which may now count from four to thirty thousand head, into herds of from five hundred to a thousand head. Now, all the half-wild cattle—*bravos*, as they

call them—have an extreme fear of man; it is dangerous to approach them on foot. They are prone to abandon their calves, and give them insufficient food. On the other hand, the cattle in small herds, or *manses*, breed much better and more rapidly. In Parana, many estanciers have, besides the droves of *bravo* cattle, four or five hundred head of *manse* cattle, which are kept to be milked; the latter live in the same campo, equally free with the others, but nearer the buildings. Nothing can be more surprising than to observe the differences in the aspect and in the productiveness of the two classes, whose conditions differ only in their having a greater or less familiarity with man. Ultimately, when these regions shall have become more populous and divided into smaller estates, the *manse* cattle will predominate, and systematic breeding will take the place of the present free-range practice; but at present the fact must be recognized that the rearing on a grand scale of the half-wild stock is the only system that gives returns; this method is, however, I am assured, competent to produce a stock equal to some of the better-managed races of Europe. The natural physical conditions under the operation of which the production of cattle must be maintained and promoted in these regions, are liable to considerable variation, even within the limited territory which I have visited.

The operation of the differences as a whole is revealed in the variations in the annual sales in the several regions. In Parana the proportion of animals sold is excessively small, being only about one twentieth of the total number of cattle for each year, but it is regular; while it rises to from one tenth to one eighth in Rio Grande and Montevideo, and to a still higher figure farther south, but is very irregular, falling sometimes below that which rules in Parana. That even the larger proportion of sales is smaller than that which obtains in Europe, is easily explained by reference to the differences in the prevailing conditions; but why such differences should exist between two regions of South America where the same system of raising is practiced, is an interesting subject of inquiry. The animals grow quite slowly in Parana, and are hardly ready to send to market till they are four or six years old, and are well developed and shapely; in the southern districts they are as a whole smaller, but are more rapidly developed, and are sold when only three or four years, or even less than three years, old. Then, while in Europe, nearly every cow is expected to give a calf each year, in Rio Grande and Montevideo the number of calves is only eighty per cent., in Parana only fifty per cent. that of the cow. In Parana the calves are nearly always born at or near the same time of the year, between September and November, while in Rio Grande and Montevideo the time of calving varies with different years, and even in the same year on different estates, and the proportion of calves is likewise irregular. The estancias of Montevideo are liable to visitations by epidemics which often carry off

thousands of head of stock; those of Parana are liable to a single affliction which is troublesome, the grub, from which the more southern districts are comparatively free. In Parana, the animal having passed his first year, continues to grow regularly and safely; in the southern districts he is exposed to many dangerous affections. The Parana animal has symmetrical proportions, a good size, well-developed bones, a thick hide well provided with hair, horns firmly planted and curved; the color only is variable. The southern stock, although faster growing, are irregular in their proportions, smaller than those of Parana, and do not give as much clear beef.

These diversities are attributable to differences in the media in which the cattle live. The seasons at Parana are regular. One, from December till the end of March, is marked by heavy rains coinciding with great heat; the other, including the rest of the months, is without rains or storms, but has abundant dews—a season of seven months of drought. The seasons are irregular in the southern regions. The winters are colder than in Parana, and are attended with heavy frosts. Long storms are not infrequent, and are often destructive to stock. The rains are not to be depended upon, but the heaviest of them fall in the winter; and the dry seasons come at irregular intervals. Calves are regularly born in the same months in Parana, because the animals, after having been exhausted by the long drought, have recovered their strength in the rich pasturage of December and January, and are in the best condition for heat in the following months. The seasons of calving are irregular in the southern districts because the times when the rains fall and the pastures are good, on which the procreative ability of the animals depends, are irregular.

These facts are very remarkable, for they show that reproduction is not regulated directly by the climate or the season, but indirectly, through the condition of the pasturage. The further development of the young animal is also affected by the same condition. The Parana calf, born during the dry season, is badly nourished at first, but finding the pastures rich just when it has grown large enough to graze, and beginning at the same time to receive an abundance of milk from its mother, it takes on a rapid development, and soon becomes strong enough to endure the coming dry season. This season carries off all the weaker animals, especially those that are calved at a later than the normal time, and has in this manner contributed to the perfection and perpetuation of the characteristics of the breed.

The case is quite different in the south, where the increase and growth of the animals are as irregular as the seasons; great losses occur under exceptional conditions of weather; and herds are sometimes reduced one half in consequence of long droughts.

The capacity of the stock in Parana to endure the long annual droughts is doubtless increased by certain accessory features in the nature of the soil and in the wooded growth. The soil is clayey, and

not easily permeable by water. It accordingly retains the moisture, and is fitted to form the bed of streams which never become dry. The pasture-lands are diversified with woods which are wanting in the more southern districts, and these give the animals shelter when they need it, and furnish them with a certain amount of browse, though it be of inferior quality, when the grass fails. There are other differences, mostly relating to matters of detail, which have not yet been sufficiently studied to make their bearing well understood, but all of which appear to illustrate the fact that the life of the stock, its increase, and its development, depend on the complex relations of certain physical conditions, such as the temperature, the time and amount of rains, the character of the soil, the presence or absence of wood, all of which act through their influence upon the supply of pasturage and food. A careful study of the media in which the cattle live and by which their development is governed and their habits are regulated, the points of difference between them, and the varying effects they produce in the animals exposed to their influence, might result in adding another page to what has been written on progressive evolution and adaptation.—*Translated from Revue Scientifique.*

BIOGRAPHICAL NOTICE OF PROF. C. A. YOUNG.

AMONG the original cultivators of astronomy who give honor alike to the American name and to the science of the age, a distinguished place must be assigned to CHARLES AUGUSTUS YOUNG, the present Professor of Astronomical Science in the College of New Jersey, at Princeton. He was born at Hanover, New Hampshire, December 15, 1834, and may be said to have had astronomy in his blood, being descended from professors of that science on both sides for two generations. His father, Professor Ira Young, occupied the chair of Natural Philosphy and Astronomy in Dartmouth College; and his mother's father, Professor Ebenezer Adams, held the same position in that institution still earlier. He fitted for college at home, and graduated at Dartmouth at the head of his class in 1853.

After graduation he was for three years a teacher of classics in Phillips Academy, Andover, Massachusetts. In 1856 he accepted the appointment of Professor of Mathematics, Natural Philosophy, and Astronomy in Western Reserve College at Hudson, Ohio, and the next year he married Miss Augusta J. Mixer, of Concord. He remained at Hudson till 1865, and during the time of his connection with the Western Reserve College his vacations were spent in astronomical work for the survey of the Western and Northwestern lakes. At the same time he deviated from his peaceful college occupations into the profession of war. He became a military captain, and commanded a company of

one-hundred-days men, mostly composed of the students of the college, who had volunteered at the call of Governor Tod, of Ohio, in 1862. The company was ordered to Vicksburg as escorts to a cartel of exchanged prisoners, and Professor Young's health received injuries during the expedition from which he has never entirely recovered.

He returned to his native town of Hanover in 1865, to take the professorship of Natural Philosophy and Astronomy in Dartmouth College, the same which had been held by his grandfather, and his father, who died in 1858. He was connected with this institution until 1877. During this time he was actively engaged on several astronomical expeditions. He was a member of the party which, under the charge of Professor J. H. C. Coffin, observed the eclipse of August 7, 1869, at Burlington, Iowa. Professor Young had devoted himself with great assiduity to spectroscopic investigations, and he had charge of the spectroscopic observations of the party. It was there that he discovered the green line of the corona spectrum, and identified it with the "1.474" line of the solar spectrum. It may be observed that Professor Harkness also discovered the same line on the same occasion, at Des Moines, though, on account of the inferior power of his instrument, he did not identify it correctly. In the winter of 1870–'71 Professor Young was a member of the Coast Survey party which, under the charge of Professor Winlock, observed the eclipse of December 22d at Jerez in Spain. It was on this occasion that Professor Young made his interesting discovery of what is called the "reversing layer" of the solar atmosphere, giving a bright-line spectrum correlative to that of the ordinary dark-line spectrum of sunlight. This remarkable effect is thus described by Professor Young, in his new work on the sun: "At a total eclipse of the sun, at the moment when the advancing moon has just covered the sun's disk, the solar atmosphere of course projects somewhat at the point where the last ray of sunlight has disappeared. If the spectroscope be then adjusted with its slit tangent to the sun's image at the point of contact, a most beautiful phenomenon is seen. As the moon advances, making narrower and narrower the remaining sickle of the solar disk, the dark lines of the spectrum for the most part remain sensibly unchanged, though becoming somewhat more intense. A few, however, begin to fade out, and some even turn palely bright a minute or two before the totality begins. But the moment the sun is hidden, through the whole length of the spectrum, in the red, the green, the violet, the bright lines flash out by hundreds and thousands, almost startlingly; as suddenly as stars from a bursting rocket-head, and as evanescent, for the whole thing is over within two or three seconds. The layer seems to be only something under a thousand miles in thickness, and the moon's motion covers it very quickly."

In August, 1872, Professor Young was stationed at Sherman, Wyoming Territory, the summit of the Pacific Railroad, to make solar

spectroscopic observations in connection with the Coast Survey party. While there he made out a catalogue of 273 lines reversed in the chromosphere spectrum, and 104 lines modified in the spectrum of sun-spots. In 1874 he went to Peking, China, as assistant astronomer in the party of Professor Watson, which observed the transit of Venus.

While at Hanover Professor Young devoted most of the time which could be spared from college duties to astronomical and spectroscopic observations, and he devised a form of automatic spectroscope which has been very generally adopted, and a description of which was formerly given in "The Popular Science Monthly." He also made a great number of new and instructive observations on the phenomena of solar prominences, and observed some remarkable explosions in the stupendous masses of vapor which are shot out hundreds of thousands of miles from the solar surface. Professor Young also, at this time, established what is known as Doppler's principle as applied to light experimentally, and was enabled to measure the sun's rotation by the displacement of lines in the spectrum.

But, notwithstanding his multifarious labors in the observatory, and at distant places which he visited for observation, Professor Young has also been active as a writer of scientific papers, and as an astronomic teacher. Besides his elaborate courses of instruction to college classes, he has also given courses of popular lectures at Peabody Institute, of Baltimore, and Lowell Institute, at Boston. He has also delivered occasional scientific lectures in different cities, and regular educational courses at Mount Holyoke Seminary, Williams College, St. Paul's School, and several other places. It must be added that he has also found time, within the last few years, to write an excellent popular treatise on "The Sun" for the "International Scientific Series," which is now just issued.

The vigorous movement in the College of New Jersey, at Princeton, for enlarged scientific teaching, which was inspired and directed by President McCosh, led to the choice of Professor Young to take the chair of Astronomy in that institution, and he accepted the invitation in 1877. In 1878 he was in charge of the astronomical expedition organized by the college to observe the eclipse of July 29th of that year, at Denver, Colorado, and in which the party had excellent success. During his residence at Princeton he has maintained his customary activity in pursuing spectroscopic observations in solar physics.

Professor Young has been honored by many recognitions of eminence in his department. He is a member of the National Academy of Sciences, a Fellow and ex-Vice-President of the American Association for the Advancement of Science, an Associate Fellow of the American Academy of Arts and Sciences in Boston, an Honorary Member of the New York Academy of Sciences, and of the Philosophical Society in Philadelphia, and a Foreign Associate of the Royal Astronomical Society of Great Britain.

CORRESPONDENCE.

COLORED MEN IN CHINA.

[We copy the following interesting correspondence from the pages of the "Southern Workman." It contains various significant facts admirably presented.]

Singapore, *May* 10, 1881.

Messrs. Editors.

In a previous letter I spoke about a negro, S. A. Butler, a resident of Shanghai, China. His career is quite remarkable. His parents were Africans, or pure negroes; his father a preacher in Washington, D. C. He was educated in Paris, and there learned to speak French, Italian, German, and Spanish. I think he has an aptitude for languages. When Mr. Burlingame was appointed Minister to Peking some years ago, he met Butler in Paris, made him his private secretary, and took him to China, where he became familiar with the *spoken* Chinese.

Mr. Burlingame always put him on a footing of social equality. Wishing to go into business, Butler left the American embassy, and took a post in one of the great American trading-houses. Subsequently he went into the service of the Shanghai Navigation Company. For some time past, the Chinese officials and some of the rich Chinese merchants have been watching carefully the operations of the Europeans in steam navigation, supported by European capital. These prudent, careful men determined that, if there was any profit in the trade, the Chinese should have it, and not the *fan qui* (foreign devil). Therefore they began to buy steamships themselves, and to run them to and from their own ports. They organized the China Merchants' Steamship Company. They put their own, and not foreign, money into it. They purchased the Shanghai Company's steamers, and Butler went into their employment. Still, these Chinese, careful and economical as they are, did not understand the business of running steamships, for it is a business which requires special training. These men were cheated by Europeans in the quality of the vessels sold, and they were held in great contempt by Europeans and Americans who kept lines of steamships in the East, and who believed that their dominion over the sea would never be successfully disputed by the "pig-tails."

The Chinese concluded it would be well to employ Europeans, at first, in the most responsible positions. But the trouble has been, that the Europeans have generally tried to rob the Chinese when employed by them. The owners of this new Chinese line, including some of the most influential men in the Chinese Government, put Butler in charge of one of the most important departments of the business, and authorized him to reorganize the service in his own way. He is a natural organizer, one of those men who know how to put things in their proper place, how to put down confusion. He systematized the business, brought order out of chaos, introduced economy, enforced discipline, and rivaled the Europeans in their steamship service. The result is, that after two years' work this Chinese steamship company, instead of running at a loss, has earned over a million dollars net profit. The prospect now is, that it will earn very large annual dividends.

The Chinese official who is at the head of the company told me that they considered Butler not only a man of great ability, but an *honest* man. He said that he was a very safe adviser, and they regarded him as an important agent in the future operations of the company. Now this Chinese company own already thirty-six steamers. They are bidding for the trade of the Pacific Ocean. One of their vessels lately went to San Francisco, and reduced the price of freight to China. The American and European lines are by no means easy at the appearance of this great steamship fleet; no one knows where its operations will stop. As these people learn more thoroughly the steamship business, they will become more formidable rivals to the Europeans, and, as they are content with much less profit than the Europeans, and the business is conducted at their own homes, and not with a distant European basis, it is easy to see that the time is soon coming when the vast trade of the great Pacific Ocean will be in Chinese hands.

Coal is an expensive article in China. Supplies for steamers are brought from Australia and Java. Now, there are immense coal-fields in China. The Chinese will not let the Europeans touch these coal-fields under any circumstances, but they can touch them themselves. Already they have opened a vast colliery about eighty miles from tide-water, at Tientsin; a canal from the mine to the ocean is about finished. The coal is owned by the same people who control the steamship company. This year

coal will be delivered to ships. If the Chinese prefer to consume the coal in their own vessels, instead of selling it to the foreign steamers, it will not take long to wipe out the foreign service, as the cost of the coal will be so much less than that now used by all steamers.

Butler is a leading man in this magnificent enterprise in China.

I have related this incident because it bears on the question of the "color-line," and I write this from a city where the presence of twenty-six different nationalities has obliterated all color-lines. There is a lesson in Butler's life. He fought for his position and won it. He did not sulk for it, or cry for it, or beg for it; he commanded it. He made himself the peer of men about him, and they acknowledged it, as all men will admit, when forced to meet the matter. Men sought him, as they always seek men who have advantages, either in brains or experience. Interested as I am in the negro question, it was to me a most important incident to meet, on the seaboard of the great Chinese Empire, an American negro, educated, capable, doing his work well, and a leader among men.

Several weeks after meeting Butler, I was with the King of the Hawaiians on board the royal yacht of the King of Siam, on the river Menam. On the way to the capital of the country, Bangkok, the yacht stopped for a moment at the custom-house, in order to take on board some officials. I noticed a negro sitting in the stern of a boat, and inquired about him. A merchant said to me: "He is at the head of the custom-house on the river. It is a very responsible place. This negro is a man of considerable education, is honest and capable; so he was appointed to the place, and discharges the duties well." I had no opportunity to speak to this man, but I counted it as another incident of my trip that I had met another negro who was doing credit to himself. I have written this letter for the sole purpose of presenting these facts to the younger colored people in America, that they may know that their race can hold itself if it will.

[Mr. Armstrong adds to the above valuable information a few notes on travel, which we are sure will interest our readers:]

The city of Bangkok contains about four hundred thousand people. Through the center of it flows a large river; from the river canals are cut in every direction; and, while most of the people live on land, very many thousands live on the water entirely. A raft is made of *bamboo*, and tied to the river-bank. A house is then built on the raft. In it one or more families live. The back part of the house, or the part toward the river-bank, is used for living purposes, while the front part, facing the river, is used for stores or manufacturing purposes. One wishing to do some shopping hires a canoe, rowed by two men. This canoe is moved along the river, and stops in front of the houses. The passenger, sitting in it, leans over the side and inspects the articles in the house on the raft; when the trade is over the canoe moves off to another place. It is, in fact, a river-carriage. These water-houses extend for three miles up and down the river. They rise and fall with the tide. In rowing the canoes or boats, the men stand up, facing the bows. The oar is fastened to a stake in the boat, and the rower dips the oar in and pushes it while standing.

About one year ago the Queen of Siam, while passing up the river in a royal barge, was run down by a steam-tug. There were numbers of people standing by, but none of them dared to rescue her, because she was sacred, and could not be touched; so the poor woman went to the bottom. Just before we arrived at Bangkok she was cremated; a vast temple was built for the occasion, and an altar of sandal-wood was erected in the center of it. In this the body was placed, and burned to ashes. Festivities continued for ten days. The total cost of the cremation was above one half million dollars. Cremation is universally practiced in Siam. In many cases the bodies are taken to a temple and exposed in the open air; vultures and carrion-birds come down in dense flocks, and consume the flesh in a few moments. The bones are then burned, and the ashes are scattered in the waters of the sacred river Menam.

The Siamese are a pleasant people, but very lazy. Rice and fish are cheap, and if the people can get this food they will not work. Few of them are forehanded. The consequence is, that the Chinese come in, get the best lands, and do the best part of the business. In the end the four million Siamese will pass away, and the country will be in the hands of the Chinese entirely. It is a case of the "survival of the fittest."

The Chinaman is the New-Englander of the Pacific in his energy and pluck. The Chinaman of the northern part of the empire does not emigrate. Though he is poor, he prefers his mud-hut and his associations to foreign lands; no inducements so far have brought him out of his home. The southern Chinese, living along the coast, in the vicinity of Canton, are the people who emigrate. All who have left are, however, but a fraction of the people in only one province. California holds seventy-five thousand of these people; Australia, perhaps, as many more. What are these numbers to the forty millions of one province alone in south China?

I do not despise their religion. Let no

one despise any religion which contains any good. The central doctrine of their religion is *ancestor-worship*. It is believed that the spirit of the father, or ancestor, wanders about in an unhappy, restless condition, unless it is worshiped. While every Chinaman worships, therefore, the spirits of his forefathers, he is always on the lookout for a son who will, in turn, worship his spirit. This is no idle business with these people. It is no Sunday affair. It will not do to meet in the temples and say we ought to worship our forefathers. They do it. It is a practical belief, which controls every man's life. The father, while living, is the head of the family, and the profoundest respect is paid to him till he dies. If a Chinaman has money, he would starve himself just as quickly as he would allow his father to go without support. Of the thousands of poor "coolies," or laborers, who have gone from China to the Hawaiian Islands to work on sugar-plantations at eight dollars per month, the majority remit money to their parents; so a missionary in Hong-Kong told me; much of it went through his hands. But the worship of ancestors requires presence at the tomb. So the Chinaman, the moment he has obtained a little money, returns home and worships at the tomb. But every Chinaman must have a son, as I have said. (Of course, under this system of religion early marriages are the rule.) Probably every one of the seventy-five thousand Chinamen in California is a married man, but has left his wife at home. It is clear to me that they would not hesitate to bring them—firstly, if they could afford it; secondly, if they felt secure of property and liberty. The Chinaman has found that, so far as he is concerned, the treatment given him by the proud and Christian civilization of America is more unjust than that of the most despotic of any *taotai* (magistrate) of his native land.

It is said in America: "Oh, these Chinese don't intend to stay; they will not mix with our people. They make money, and go home!" True! But here are some twenty "treaty ports" in China and Japan opened to Europeans and Americans. These people come here, engage in business, make money, and go home. There is not an Englishman, or a Frenchman, or an American, or a German, who does not frankly admit that he came here to make money, and that he shall return home at the earliest possible moment to spend it. Make one of these foreigners believe that his life must be spent here, in the East, and he would look about for his razors.

Here, in Singapore, the Chinese are at the head. Look at the map, and you will see the commanding position of this place, at the southern extremity of Asia. Here the trade of the East centers. The English took it over sixty years ago, when its population numbered about four thousand, all Malays. Now there are one hundred and thirty-seven thousand people, and of these sixty thousand are Chinese, who have come from China, a thousand miles away. All that is valuable, in the way of trade, or business of any kind whatsoever, is in their hands. The Malay can not stand against them for a moment. They outdo him at every turn. Trade from Japan, northern China, the Malaysian peninsula, the vast archipelago of immense islands which include Sumatra and Borneo, stretching away for three thousand miles to the skirts of the Australian Continent, centers here. Thirty languages are spoken, but the Malay is the language of trade, because it is easy to learn. Though, as I say, the Malaysians are of little account here, they were, at the start, the dominant race, and their language became the medium of conversation between the score of races which meet here. Though they have got into the background, in the great struggle, they have left their language to the common use, till some other takes its place.

The similarity of the Malays to the Hawaiians is striking. Though these two nations are five thousand miles apart, and there is no tradition of any intercourse in the ancient days, even the languages have words in common. For death, the Malay says "mate," the Hawaiian says "make"; for eye, the Malay says "mata," the Hawaiian says "muka." For want of thrift, laziness, and supreme indifference to the future, the Malay and Hawaiians are one and the same. The Chinamen will soon be masters of the situation here, and the Malay will submit to it.

W. N. A.

HARVEST-MITES OR JIGGERS.

Messrs. Editors.

THE minute creature about which Dean V. R. Manly asks for more definite information, in your September number, is undoubtedly the *Leptus Americanus*, described and figured by me six or seven years ago in the "American Naturalist." It is a minute, six-legged mite of the genus *Leptus*, now generally recognized as but the larval form of some eight-legged *Trombidium*. Being away from home, I can not now give you the exact references, but may send you more particulars at some future time. Respectfully,

C. V. RILEY.

ALBANY, NEW YORK, *August* 31, 1881.

EDITOR'S TABLE.

DR. FAIRBAIRN AND THE SYNTHETIC PHILOSOPHY.

IT was the aim of Bacon to bring the great divisions of knowledge into unity. Tired of the sterility of the old philosophies, he proposed a new one that should be both a true interpretation of nature and lead to grand utilities. He divined the method, but his imagination outran the resources of his time, and he could not execute it.

Three centuries of science have now made the fulfillment of Bacon's conception not only possible, but an imperative intellectual necessity; and, among the thinkers of this age who have most clearly perceived and most strongly felt the need of attempting this formidable task, is Mr. Herbert Spencer. He entered upon it as a life-work, and has now devoted twenty-five years of unremitting thought to the undertaking. As his system is predominantly constructive—a binding together of different orders of ideas by far-reaching principles—he has called it "The Synthetic Philosophy." It is now in its main features an accomplished fact, and its appearance is probably the most considerable intellectual event of our times. The periodical press is slow to note the significant incidents of its progress, and so nothing remains but for "The Popular Science Monthly" to repair the omission.

The project, in the nature of the case, was extensive, and it was certainly a worthy thing for a man of ability to forego the common aims of ambition, and dedicate his powers to what required prodigious work, and was even then generally thought to be impracticable and impossible. But, noble as was the scheme, it was neither received with the sympathy nor sustained with the liberality that such an undertaking deserved. Nevertheless, Spencer's system of thought has made its way so successfully as to have become of cosmopolitan import before it is yet completed. His elaborate works have been reproduced in all the leading modern languages, and they are making a powerful impression upon the cultivated mind of the different countries where they are circulated. They are ably criticised in the leading reviews of these countries, and books are multiplying on every hand, directed to the exposition, defense, and refutation of their doctrines.

We have referred to the unfavorable reception of his system. That his views should have met with a formidable resistance was natural and proper, but criticism did not stop here. The attacks of reviewers were too often accompanied by gross personal disparagement. His adversaries, assuming themselves to be the guardians of great and sacred interests, often wrote with passion, and indulged in the tone of depreciation wholly foreign to the purposes of honorable controversy. The critics are, however, beginning to find that nothing is gained in the long-run by such unfairness. The system pronounced worthless and impotent, or potent only for mischief, is steadily gaining upon the world's favorable appreciation. Spencer has been again and again ostentatiously "crushed," and all men called to witness how the dust of his unsubstantial reputation has gone to the winds. Yet there stands the solid fabric of his labors unharmed, the stronger for every attack, and becoming more stable with each addition as its author steadily proceeds with his task.

What we are now called upon to

note is that the abler men who have latterly ventured to cope with his thought no longer disparage him. In this respect there is a marked change of tone on the part of his critics. They recognize that his work has in it great elements of valuable influence, worthy of cordial praise and even of emphatic eulogy.

This more liberal spirit is well illustrated in a recent English criticism of Spencer's doctrines that is attracting attention. Principal Fairbairn, of Bradford, was appointed to deliver the "Muir Lectures" at the University of Edinburgh last winter, and recognizing the growing influence of the synthetic philosophy he devoted three of these lectures to an examination of it. They were reported at the time, and awakened so much interest that the author was led to make an extended restatement of his case, which has appeared in the July and August numbers of the "Contemporary Review."

Dr. Fairbairn is a subtle and thoroughly trained metaphysician, and he devotes himself mainly to an attack upon the introductory portion of Spencer's scheme, where he discusses the limits of knowledge to find the true sphere of philosophy. With Dr. Fairbairn's general argument we have here no concern, but are interested in its opening passage, which reads as follows:

> Mr. Herbert Spencer's philosophy has at least one conspicuous merit—it can claim to be the most comprehensive, or rather ambitious, of English philosophies. It is, in its psychology, distinctively English and empirical; but, in its spirit and endeavor, distinctively encylopedic and transcendental. In many respects its constructive and comprehensive character entitles it to cordial admiration and praise. Its outlook, backward, forward, and outward, is so immense that it powerfully affects the imagination, which the traditional philosophy of England has, with the splendid but only the more illustrative exception of Berkeley, been too prosaic and narrow to touch or to stir. To conceive a system so positive and universal as Mr. Spencer's is in itself an education to an age, and its extraordinary influence is an evidence that the modern intellect is neither so skeptical nor so critical as it is said to be, but loves, as intellect ever has done, to believe a system, stated in terms it thinks it understands, that promises to explain the universe presented to its senses and represented in its thought. The English mind has been rather inclined to make merry over the philosophies of Germany, especially the Hegelian, which has so adventurously essayed to fit the universe into its dialectic network; but the approbation which has greeted Mr. Spencer's attempts at a "synthetic philosophy" is proof enough that the English contempt for transcendentalism is due to insular peculiarities, not to say ignorance, rather than to intellectual disability or insufficient sympathy with constructive aims. His system, indeed, seems so little metaphysical, so concrete, intelligible, real, it so speaks the language of science, is made so striking by brilliant generalizations, and so vivid by abundant, even superabundant illustrations, that it has come, to a people inclined by their mental habits to despise metaphysics and respect science, almost as a revelation of the true nature and method of creation.

This is a novel strain for an adversary of Spencer. It is no small compliment to pay a system of thought that its largeness and power are attested by its influence upon the national mind, and that even during its promulgation. It may seem ungracious not to accept so generous a statement as wholly satisfactory; but, in accounting for the "remarkable influence" ascribed to Spencer's system, Dr. Fairbairn seems strangely to have missed what we regard as its most important element. He recognizes its ambitious claims and its specious character, which make their appeal to a deficient national culture; but he was not ignorant that this system has in it also sterling elements which have made their successful appeal to the most sober and thoroughly instructed minds of England. Admissions made in the course of his discussion, if placed at its threshold, would have very materially altered the complexion of the opening passage we have quoted.

Although combating various of Spencer's positions, chiefly on the metaphysical side, Dr. Fairbairn fully accepts the doctrine of evolution. Many give it a cautious and qualified approval in the lower sphere of life. Dr. Fairbairn takes it without reservation as a comprehensive law, true not only in the domain of inferior life, but also in the higher sphere of humanity, and emphatically in the realm of religious sentiments and ideas. He says: "There is to be no attempt here to question or deny the doctrine of evolution; it is indeed frankly accepted. . . . The creational method is here held to be evolutional. Its history narrates a progress and exhibits a process best named developmental. Without this notion a philosophy of religion were impossible, for without it there could be no scientific study of man and his religions. We can not refuse to apply the principle or idea that underlies and vivifies the study of man in history to the interpretation alike of man and nature, to the master-problems that relate to their being and becoming, to their birth and growth."

Now, this great principle is the pervading and characteristic idea of the synthetic philosophy. It is there first expounded as a universal law, developed as a method of thought, and carried out in its main applications. Dr. Fairbairn holds it to be true, and a truth of such moment, that its establishment makes an epoch even in the study of religion. But is this fact that Spencer's system has a great and all-influencing truth at its foundation which he has so profoundly mastered that he has been enabled to throw it into philosophic form—is this fact to count for nothing in estimating the elements of its admitted "remarkable success"? What kind of a notion has Dr. Fairbairn of the value which his readers attach to the quality of truthfulness in systems of thought submitted to their judgment? We propose to show that what he has here overlooked is precisely that attribute of Spencer's system which has been most potent in commending it to the best intelligence of the age. It not only "speaks the language of science," but it embodies the truths of science, it organizes the principles of science, it conforms to the methods of science, it is a scientific philosophy; and the hostility it has encountered on the one hand and the favor that has been extended to it on the other are due to its supposed identification with science in spirit, substance, and method.

Dr. Fairbairn's omission to recognize this fundamental trait of Spencer's system, when accounting for its extensive influence, may not have been intentional, but it is significant. What is the state of mind that could allow such an oversight? It is simply the general state of mind exhibited by our so-called cultivated classes toward scientific truth. Let us see what this is.

Opposition to science is not the exclusive reproach of any one school of thought; it has been manifested by all. Theology withstood science, because it was itself identified with the old erroneous explanations of nature. Philosophy made a stand against science, because science circumscribed its field and subverted its ideals. Literature strove against science, because of its devotion to fact and its supposed unfriendliness to imagination. Art resisted science as unfavorable to the inventive and creative spirit. Science studied matter to understand its mysterious processes and discern its laws; the schools of culture all contemned the occupation of mind, and shrank from it as a descent into groveling materialism. Philosophy was most potent in its opposition, because it gave law to education and gave reasons to theology, literature, and art.

The antagonism of so-called philosophy to the scientific spirit was inevitable. In the childhood of knowledge it entered upon speculations which could

yield no valid results, and came at length to consider that valid conclusions, being impossible, were undesirable. But, as active thought could not be stopped, it was concluded that the virtue of philosophy consists merely in the mental exercise it involves. And, as philosophy had proved useless as a means of arriving at assured truth, its uselessness was claimed to be a merit. And so utility, or the value of results attained, both in themselves and in their practical service to man, was explicitly repudiated. Alike in old Greece and in modern Germany—from Plato to Hegel—this has been the philosophic teaching, and we have seen the doctrine solemnly promulgated in our own times. Sir William Hamilton, as is well known, opens his lectures on metaphysics and logic with a formal defense of it. He maintains that the pursuit of knowledge by man for any end beyond himself—that is, for any practical benefit, private or public—is nothing less than debasing. It is a degradation of the ideal of scholarship. He says that the attainment of truth is not the proper object of mental activity, but the pleasure of the pursuit of truth. To seek is noble; but to seek successfully—that is, to find the object sought—is a calamity, because it ends the gratification of the search. The founder of a modern and influential school of philosophy ransacks antiquity and ranges down all the dark ages after authorities who have held this doctrine, and his case is fully made out.

Now, when this old philosophical notion that truth, for itself and for its uses, is not the proper end of study, is still theoretically maintained in our colleges and universities to be the first law of all liberal education, we need not be surprised at the extent of the ignorant prejudice against science, and that the influence of this prejudice should still be widely manifested. Illustrations of it appear everywhere. We pick up the last number of "Scribner's Monthly," and this is the way it talks to its hundreds of thousands of readers:

> We doubt whether what we call literature will ever be indebted to science or what is recognized as "the scientific spirit" for anything good. Science deals with matter, its essence, laws, phenomena. Its tendency is to materialize everything. Life itself is evolved from matter. Its "promises and its potencies" are found in that. The tendencies of science are to count God out of the universe, to deny immortality, and the existence of mind independent of matter, and to believe nothing that can not be demonstrated. Hard material facts are the things with which science deals, and it refuses to have to do with anything else. It refuses to recognize the existence of anything like imagination except in a scientific way. Imagination is a product of molecular action in the brain. Science must necessarily deny to this faculty of the soul any legitimate functions because it can not follow a scientific method, and because it denies the existence of the realm in which it is most at home. Imagination must have an over-world in which to spread its wings, or it can not fly. To bind itself to demonstrable facts and to tie itself to a scientific method would be to commit self-destruction. To circumscribe the horizon of the poetic faculty is to clip its wings, or, rather, to deny it space for action. It is a faculty that demands illimitable space, illimitable time, illimitable freedom of invention, release from bondage to the material and real, and liberty to explore the spiritual and the ideal. Any influence or power which interferes with this liberty in any direction is a foe to poetry and a curse to literature.

Crude and ridiculous as this statement is, it represents a widespread feeling. The fact is that, so long as science sticks to the manipulations of matter, it is let alone; but, when it comes forward with its revelations of the constitution of nature, and asserts that these must in future affect all the higher departments of thought, it is met with denunciation from every school of cultivated ignorance which grew up before scientific knowledge arose. This explains the ill-will of multitudes toward Spencer's system. It represents science in its most obnoxious aspect, in carrying its method into the field of general ideas.

But we have here also an explanation of the powerful hold of this system on the instructed and independent mind of the period. Dr. Fairbairn truly says that "to conceive a system so positive and universal as Mr. Spencer's is itself an education to an age." But more than this is true; for if, as confessed, this system has attained a "remarkable influence," that influence has actually been an educational power on a great scale. What is it that Spencer has brought to his contemporaries which they had not before, and which is so adapted to the general condition of thought that barely to conceive it is "an education to an age"? Dr. Fairbairn having omitted the most important answer to this question, we are now prepared to give it for him.

Mr. Spencer, as we have intimated, has first given to the world a philosophy that is an outgrowth of science, and answers the clear requirements of advancing knowledge. The older philosophy, with its lofty scorn of truth as an end and its emptiness of everything useful, had so trifled with the common-sense of mankind that its very name fell into reproach. Spencer has redeemed it and vindicated its rightful supremacy by showing that its sphere is the realities of nature and experience, and its function to formulate the deepest interpretation and the widest ascertainable truth of the universe. Philosophy, as he views it, is not merely a skillfully reasoned body of speculation; it is nothing, if not true—nothing, unless it compels assent as the highest of verities. Science passes into philosophy as it furnishes generalizations from all orders of phenomena which merge into truths that are universal. Claiming no ideal perfection or completeness, it gathers established principles from all scientific sources into systematic expression, and thus acquires a harmony as perfect as the discovered harmonies of nature, and a unity as absolute as the demonstrated unity of the universe. The formation of such a philosophy implied a reorganization of knowledge that should bring its hitherto diverse branches into closer relations of dependence, the separate orders of truth into higher coördination, and thus give a strength to the fabric derived from the validity of its scientific elements. Such a philosophy must widen its scope and grow ever more consistent, more congruous, and more comprehensively unified with every extension of knowledge. Who expects that the transcendental and metaphysical systems will ever be brought into mutual confirmation or any possibility of agreement? Concord has only given us a new illustration of the old and hopeless discord. Spencer's philosophy has made its auspicious way because it gave to the age what it imperatively needed. Men were wearied by futile speculation on the one hand, and appalled by the growing details of science on the other; and they wanted a higher synthesis of verified truth, a constructive philosophy of science. It is as a new *organon* of knowledge that Spencer's philosophy has gained its commanding influence over the active mind of the period, and it is this trait that has made it one of the most widening, elevating, and potent educative agencies of the age.

Another feature of the synthetic philosophy, though implied in what has been said, is so important in accounting for its "remarkable influence" that it requires to be brought out more explicitly. Spencer's system is sharply contrasted with preceding philosophical systems by its recognition of the great value of knowlege for useful ends. His philosophy is animated by a grand utility. Holding that truth is to be supremely valued for its own sake, and that philosophy is justified in its truth alone, Mr. Spencer finds that the highest truth involves also the highest good, and his system thus becomes nobly tributary to the advancement of human welfare. Science has sufficiently exem-

plified the worth of mental acquisitions for practical purposes, and points to its conquests over the material world as proofs of its useful services to man. But it is a far higher service to have disclosed the true method of nature and determined man's real position in the universe; because only as these are understood can human conditions be permanently improved. Spencer's philosophy assumes this higher sphere of beneficent influence, and throughout its whole development it bears upon the final and regnant problem of the regulation of human conduct. Each division of his system has its intrinsic interest as a new exposition of principles determined by the great reorganizing law of evolution; but "First Principles," the "Principles of Biology," the "Principles of Psychology," and the "Principles of Sociology," are only so many foundations for the ultimate exposition of the "Principles of Ethics." The constitution of nature as an ever-unfolding order, the laws of life, the laws of mind, and the laws of social relation, are successively expounded with a view to their final bearing upon the right and wrong of human actions.

The inspiration of these labors was a profound interest in the moral welfare of society; and there are many who can now appreciate the sagacious forecast that could discern an approaching emergency of thought for which it was imperatively necessary to prepare. While yet the idea of evolution was derided as a fanciful conceit of visionary minds, Herbert Spencer knew that it was soon to become the governing law of the world's best intelligence. He saw that, among the great changes that would follow, the traditional theories of morality would be sure to suffer irreparable damage, and that morality itself might lose its force if not fortified by a new authority. The synthetic philosophy was accordingly laid out in its complete logical order more than twenty years ago, to meet the inevitable emergency that has now arisen, and the wisdom of this prescience is attested by the eager interest with which the "Data of Ethics" was lately received in every civilized country.

The aim of Spencer's philosophy is, therefore, to organize that scientific knowledge of nature and human nature which shall be most valuable for guidance, alike of the individual in his personal and private sphere, and of society in its relations with the individual. This system establishes the principles by which the freedom of the citizen and the duty of the state are determined. There, as nowhere else, we are shown the growth and conditions of human liberty, and the forces that have hindered and the forces that have promoted its progress.

Nor has the reader to go far for evidence of what we say. The last installment of his system that Spencer has given us is luminous with new instruction upon this subject. The article on "The Militant Type of Society"—long, but not too long—printed in the present number of the "Monthly," exemplifies in an impressive if not a startling way the obstructive agencies of social progress. A succeeding article on "The Industrial Type of Society" will complete the view by showing what causes have been most powerful in producing beneficent social and political effects. The reader will find in those papers exemplifications of the enlarged utility which dominates Spencer's system, and for which he will look in vain in any preceding philosophy.

These, then, are the leading reasons why this system of thought has attained its "remarkable influence," and merely to conceive which "is itself an education to an age." But if the bare conception of it, even before it is finished, has so benign and improving an influence, what may we not expect from it when it is studied and understood, and becomes a power in the public

mind? Self-education is the only true education, and, if young men want a liberal education of practical value, let them master the synthetic philosophy and be their own teachers.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES.—NO. XXXIV.

The Sun. By C. A. Young, Ph. D., LL. D. With numerous Illustrations. D. Appleton & Co. Pp. 321. Price, $2.

The first thing we have to say about this attractive and admirable little volume is, that it was sorely needed. It was wanted, not only because of the great interest of the subject, but because we have no work in English that deals with it in any satisfactory shape for general use. Proctor's book on the sun, notwithstanding its author's astronomical reputation, is, after all, little more than the compilation of a professional book-maker. He has used his copious materials freely, and made his book too large and expensive, and too crowded with matter of secondary interest, to meet the popular requirement. It has, therefore, not been held as even worth stealing. The great treatise on the sun, of the late Father Secchi, of Rome, though written by an eminent astronomer who has worked at the subject extensively himself, is likewise too voluminous, and also too scientific, for general purposes, and it has accordingly not been thought worth translating into English. The book of the Frenchman, Guillemin, though small enough, is all too popular, and is so variously deficient as to have no true standing. A new book, compact in form, and thoroughly trustworthy for reading and reference, was greatly needed, because the knowledge that has grown up in recent years concerning the great central body of the solar system is not only of exceeding interest, but is such as well-instructed people can not afford to be without.

But it was no easy thing to get the book required. First-class scientific men are always pressingly occupied, and they very rarely take to book-making unless for the promulgation of their own views. The managers of the International Scientific Series have, therefore, been fortunate in securing a strong book on this subject, although they have had to wait a good while for it. Yet those who have been long and impatiently expecting it will now be rewarded for their waiting. Professor Young is an authority on "The Sun," and writes from intimate knowledge. He has studied that great luminary all his life, invented and improved instruments for observing it, gone to all quarters of the world in search of the best places and opportunities to watch it, and has contributed important discoveries that have extended our knowledge of it. The reader who glances at the summary of his life-work, given in an accompanying biographical sketch, will see why, of all men, he was perhaps the best prepared to report on the present state of solar knowledge. He, at all events, had the first qualification for the task, because he knew whereof he affirmed.

And he has executed the work in a manner worthy of the subject, and of his reputation. He has stated what is known about the sun in a form excellently suited for general apprehension. It would take a cyclopædia to represent all that has been done toward clearing up the solar mysteries. Professor Young has summarized the information, and presented it in a form completely available for general readers. There is no rhetoric in his book; he trusts the grandeur of his theme to kindle interest and impress the feelings. His statements are plain, direct, clear, and condensed, though ample enough for his purpose, and the substance of what is generally wanted will be found accurately given in his pages. The key to his treatment is contained in the following passage from the preface: "It is my purpose, in this little book, to present a general view of what is known and believed about the sun, in language and manner as unprofessional as is consistent with precision. I write neither for scientific readers as such, nor, on the other hand, for the masses, but for that large class in the community who, without being themselves engaged in scientific pursuits, yet have sufficient education and intelligence to be interested in scientific subjects when presented in an untechnical manner; who desire,

and are perfectly competent, not only to know the results obtained, but to understand the principles and methods on which they depend without caring to master all the details of the investigation. I have tried to keep distinct the line between the certain and the conjectural, and to indicate as far as possible the degree of confidence to be placed in data and conclusions."

It is unnecessary further to dilate on the merits of this volume, especially as the readers of "The Popular Science Monthly" are not unacquainted with Professor Young's skill in scientific exposition; nor will it be possible, in any notice, to illustrate the richness of these pages in striking facts, felicitous illustrations, and lucid explanations, concerning the constitution, astronomical relations, and stupendous influence, of the solar body. There is an introduction on "The Sun's Relation to Life and Activity upon the Earth." This is followed by a systematic discussion of the main problems of solar phenomena, in a succession of chapters treating of "The Distance and Dimensions of the Sun," the "Methods and Apparatus for studying the Surface of the Sun," "The Spectroscope and the Solar Spectrum," "Sun-spots on the Solar Surface," "Periodicity of Sun-spots, their Effects upon the Earth, and Theories as to their Cause and Nature," "The Chromosphere and its Prominences," "The Corona," and "The Sun's Light and Heat." The concluding chapter is an excellent "Summary of Facts and Discussion of the Constitution of the Sun." An appendix is added, which has been contributed by Professor Langley, one of the most zealous and successful American cultivators of solar astronomy. It presents certain important views, which this investigator has reached, with regard to the light and heat of the sun.

Professor Young's book is not written in rhyme, and does not profess to be "poetry." Perhaps it is inimical to poetry, as it deals with hard scientific material facts, and, if these are truly incompatible with poetic thought, the book will be open to the maledictions of all who consider error better than truth for the purposes of the poetic mind. But this, at any rate, may be said: no one can read Professor Young's book without recognizing very clearly that the sun, as interpreted by the science of to-day, is a far grander and more impressive object of thought than was the sun of a century or two ago. Milton traversed the universe of his time with intrepid imagination, but what was his conception of the "powerful king of day," compared with the conception of the sun which science has now shown to be true? The poetic imagination has never pictured anything to be compared with the sublimity and unspeakable grandeur of the all-regulating, life-giving star round which we are revolving, and which, so far as the human mind is concerned, science may be said to have created. Has not science, in this and kindred exploits, given a transcendent enlargement to the sphere of the imagination? We do not believe that ignorance is the mother of legitimate devotion or of genuine poetry; and those who think that the truth-seeking faculty in man, which, in a certain aspect, is simply occupied in extending the realm of wonder, and disclosing the beauty, the harmony, and the magnificence of Nature's operations, is the enemy of real poetry, have a good deal yet to learn about the subject. It will damage no sound poet to absorb the contents of Professor Young's book.

Chinese Immigration in its Social and Economical Aspects. By George F. Seward, late United States Minister to China. New York: Scribners. 1881. 8vo. Pp. xv–421. Price, $2.50.

Reserving for a possible future volume the question of "the political and commercial issues" involved in the Chinese question, Mr. Seward limits himself in the present work to its social and economical aspects, as those which are likely to determine the legislative action of the country. These aspects he considers under the following heads: 1. The number of Chinese in the United States; 2. The material results of Chinese labor in California; 3. Objections to Chinese immigration; and, 4. Fears of an overflowing immigration.

And—1. The number of Chinese in this country has been habitually over-estimated by the anti-Chinese partisans. In California it was common to hear it said, a few years ago, that there were "more Chinamen than voters" in that State The facts have

been carefully studied by Mr. Seward from the customs statistics of arrivals and departures, and from the recent census; and it turns out that there are no more than ninety-seven thousand Chinamen in the United States, of whom one half live in California, where they form about one in seventeen of the population, and enjoying such provisional security of life and property as the other sixteen see fit to permit them. During the past few years the number of resident Chinese has somewhat diminished, owing in part to the resident Californian's conviction, which he has not failed to express in practice, that the pagan element in a Christian population should be discouraged. This conviction, if we may trust the evidence of Commissioner John A. Swift (p. 250), would seem to be increasing. "In 1852," says Mr. Swift, "the Chinamen were allowed to turn out and celebrate the Fourth of July. In 1862 they would have been mobbed. In 1872 they would have been burned at the stake." This spirit may be profitably contrasted with that of a memorial written by a Chinaman resident in this country (p. 245): "If the spirit be noble and good, although the man be poor and humble, we honor and love him. But we affirm that the people of your honorable country dislike the Chinese because they see the plain appearance and the patched clothes of our poor, and do not think how many spirits there are among us whom they could respect and love."

2. The results of Chinese labor in California are considerable. In railroad-building, in farming, fruit-culture, and the reclamation of swamp-lands, in mining and manufacturing, and in such special industries as cigar- and shoe making and laundry-work, they have been of particular service. Governor Low estimated that four fifths of the grading on the Central Pacific Railroad was done by Chinese laborers. Mr. Charles Crocker, one of the builders of that road, testified before the Congressional investigating committee: "If I had a big job of work that I wanted to get through quickly, and had a limited time to do it in, I should take Chinese labor to do it with, because of its greater reliability and steadiness, and their aptitude and capacity for hard work. They are equal to the best white men." On this point, however, there is some discrepancy in the evidence, one estimate being that three Chinamen are needed to do the work of two first-rate white laborers. In domestic service the Chinese hold an unquestioned place. No one who has had experience of them will underrate their intelligence and faithfulness. A great want of the American community is that of good house-servants. To what is the lack of supply due? To our liberal institutions, the spirit of which makes domestic service of any kind seem degrading in American eyes, and even after a short term of residence in the eyes of the European immigrant. But, in the case of the Chinese immigrant, who, it is complained, does not "assimilate" with us, this moral condition is not set up. This lack of assimilability may be owing to our inquisitorial treatment of him; but it will be time enough to decide whether he will assimilate, or wishes to assimilate, with us, when we shall have admitted his rights as a human creature. Meanwhile, as Mr. Seward might have pointed out, it is precisely because he does not assimilate that he makes the best house-servant that our community has yet seen. He has no thought of becoming an alderman or a mayor, or of being promoted from the kitchen to Congress. He comes to do the day's work for the day's wages; he does it faithfully and contentedly, and there the matter ends. If American politicians have taken pleasure in the rapid assimilation of the Celtic contingent in our immigration, American housekeepers, on the other hand, would welcome a class of servants a little less in haste to assimilate, and a little more disposed to serve. If the American home is in danger of extinction, as some foreign critics have predicted, and our families are to be driven into hotels for the lack of cooks and chambermaids, it will not be because a race of real servants could not be brought from China.

3. The main objection to Chinese immigration, as already intimated, is political, and not social. Political equality, political availability, have been made the test, and unjustly so. Mr. Seward reviews other grounds of objection in detail, and concludes by saying: "I dispute earnestly the statement that they are a servile class; that

they interfere with the labor of our people; that they send money out of the country; that they have set up a *quasi* government of their own upon our soil; and that they do not accommodate themselves to the requirements of our life." That they are a vicious people has been argued from their sexual immorality, which, however, is not greater than would be expected in a celibate community like that of the Chinese in California.

4. As to the fear of an overflowing immigration of the Chinese, in case immigration should be freely permitted, the fact is that the Chinese are not, and never have been, a migratory people, but are, on the contrary, more strongly attached to their native soil than the people of any Western nation—except, perhaps, the French. They have not even "settled up" their own outlying districts, as Formosa, central and northern Manchooria, and the vast regions of inner Mongolia. And it is to be added that the demand for Chinese labor in California lessens yearly as the country is cleared up. The whole question is one that could safely be left to the operation of natural laws, social and economic. As it stands, it has been sadly muddled by governmental interference.

Mr. Seward does not deal with the philosophic aspects of the question, though they are constantly suggested by his book. One can not leave it without perceiving, for instance, the strong side of the Chinese conservatism. The rulers of China see that conservatism, ancient routine, the established order of things, mean a condition of stable equilibrium for the people, or, in the terminology of our day, that the individual nation is adjusted to its environment; and they wisely refuse to break up this adjustment by the too hasty introduction of foreign works or devices of any kind. At the present writing the Chinese policy seems to us a sounder one than that of Japan, where the changes introduced within twenty years are such as to imperil the institutions which had been perfecting themselves for many centuries. But inquiries like this are outside of the province of this work; meanwhile, Mr. Seward has given us a full, intelligent, and temperate treatment of the whole question of Chinese immigration, which, he thinks, within bounds, would be wisely encouraged.

Discovery of Palæolithic Flint Implements in Upper Egypt. Py Professor Henry W. Haynes. Pp. 5, with Seven Plates.

MM. Brugsch, Mariette, and Chabas, have denied that any palæolithic implements occurred in Egypt; M. Arcelin, Dr. Hamy, M. Lenormant, the Abbé Richard, and Sir John Lubbock, have asserted that they have found them. The general impression has been that the stone implements of Egypt, which were always used ceremonially in the embalming process, were all neolithic, and of historic times. The author went to look for himself, and claims that he found near Cairo, and near Helouan, in the desert, and in the valley west of Thebes, palæolithic implements of the true St. Acheul type, with the other forms that usually occur with them, some of which were exhibited in Paris, and have been referred to in articles by M. de Mortillet and himself, which have been published in "The Popular Science Monthly." Sixty illustrations of the implements are given in the plates to the present work.

A Memorial of Joseph Henry. Published by order of Congress. Washington: Government Printing-Office. Pp. 528.

A public commemoration of the services of Joseph Henry in behalf of the Smithsonian Institution and of scientific progress in America was held, under the auspices of the Regents of the Institution in conjunction with the two Houses of Congress, on the 16th of January, 1879. The present volume contains the *verbatim* report of the proceedings on the occasion, published under the direction of Congress, together with the addresses which were delivered at other memorial meetings, of Princeton College, and several scientific societies. In the memorial services at the Capitol, Professor Asa Gray, in behalf of the Board of Regents, gave a brief statement of the life, studies, experiments, discoveries, and general scientific work of Professor Henry; Professor W. B. Rogers made a special review of his electrical studies and discoveries. Mr. Garfield showed how, when

all others had failed, he solved the true meaning of Smithson's bequest in a way of which the world has recognized the correctness, and Mr. S. S. Cox how he had labored to give that meaning effect; and General Sherman bore testimony to Professor Henry's personal qualities as a scientific teacher and guide; while the Hon. Hannibal Hamlin demonstrated the satisfactory manner in which he had managed the financial and material interests of the institution, and the excellent condition in which he left it. To these minutes are added a memorial discourse by Samuel B. Dodd, and reminiscences by Professor Cameron, at Princeton College; the discourse of President Welling, of Columbian University, before the Philosophical Society of Washington; the discourse by William B. Taylor before the same body on "The Scientific Work of Joseph Henry," full and elaborate enough to make a volume by itself; and addresses by Professor J. Lovering, Professor Simon Newcomb, and Professor A. M. Mayer, before the American Academy of Arts and Sciences, the National Academy of Sciences, and the American Association, respectively. The special subject of the last address is "Henry as a Discoverer." The recognition of the simplicity, gentleness, and strict integrity of Professor Henry's character is a distinct feature in all of the addresses.

Anniversary Memoirs of the Boston Society of Natural History. Published in Celebration of the Fiftieth Anniversary of the Society's Foundation, 1830–1880. Boston: Published by the Society. Pp. 635, with 44 Plates. Price, $10.

The Boston Society of Natural History, having completed its fiftieth year in 1880, celebrated the event by a jubilee meeting on the 28th of April, and by the publication of this noble volume, containing the history of the Society and a number of special scientific papers. The book is a worthy memorial of the work of one of the oldest and most active of American scientific societies, and does justice to the part which that body has taken in the promotion of scientific research and the extension of scientific knowledge in the United States. The history of the Society is given from year to year, and by periods of ten years each, with a minuteness of detail which records every gift of specimens, every trouble from the ravages of insects in the museum, and even such matters as the passage of a resolution forbidding smoking in the room—things which may seem superficially of little interest, but which are instructive enough to justify their place, for they show how the life of the Society was maintained, what mistakes it made, and what difficulties it had to encounter. These features and accidents are such as are common to all similar societies, and this frank setting of them forth, as lessons of experience by which other bodies may be guided to the wisest management, is a good work. The present Society was preceded by the Linnæan Society of New England, which was founded in 1814, and was the first organized effort to excite the interest of the American public in natural science. It had a successful and prosperous career for several years, but finally died out because it depended entirely upon the voluntary effort of men whose time was already wholly occupied with their own business for its maintenance and the care of its collections. The museum—a fine one for the period—was given to Harvard College, which promised to provide a building for it and did not, and consequently it was nearly all lost. The Boston Society of Natural History was founded in 1830, on the same plan as the Linnæan Society, and by the same leading men, and would probably have met the same fate, but that it came into the possession of a fund sufficient to put it on a firm footing and enable it to employ special curators for its collections. Its early history is an epitome of the earlier development of scientific thought in this country, and, in its later history, it has kept pace with the broadest expansion of that thought. Its contributions to knowledge, as related in the yearly records, appear important and valuable when regarded in detail, and give, when summed up, occasion for satisfaction that we have had such a body laboring so long and so industriously to lead the public to higher objects of study, and that its vigor is still waxing. Not the least important of the works of the Society has been the institution of the practical scientific lectures to teachers, with object-illustrations, for the

purpose of introducing better methods of instruction into the public schools. Besides the annals of the meetings and work of the Society, the memorial contains notices of the lives and labors of its members, officers, and benefactors, who have died during its existence, accompanied with nine portraits. In the "special scientific papers" are included articles on "The Classification of Lavas," by N. S. Shaler; the "Species of Planorbis at Steinheim," by Alpheus Hyatt; "The Devonian Insects of New Brunswick," by S. H. Scudder; "The Cedar-Apples of the United States," by W. G. Farlow; "A Structural Feature in Deep-Sea Ophiurians," by Theodore Lyman; "The Development of the Squid," by W. K. Brooks; "Limulus Polyphemus," by A. S. Packard, Jr.; "The Milkweed Butterfly," by Edward Burgess; "The Development of Double-headed Vertebrates," by Samuel F. Clarke; "The Tongues of Reptiles and Birds," by C. S. Minot; "A Special Anatomical Study in Birds," by E. S. Morse; "The Crania of New England Indians," by Lucien Carr; and "The Feeling of Effort," by William James.

Indigestion, Biliousness, and Gout in its Protean Aspects. Part I. Indigestion and Biliousness. By J. Milner Fothergill, M. D., Member of the Royal College of Physicians of London. New York: William Wood & Co. Pp. 320. Price, $2.

This is a book for the medical profession, and a very valuable one, as it is based upon the latest scientific knowledge brought to the test of practice. Physiology and animal chemistry have made sure and very important advances in late years, so that the fundamental changes of digestion, nutrition, and excretion are far more clearly understood than formerly. Physiology, treating of the normal operations of the living system, is the basis of all knowledge of perverted or diseased action, and this book is written from a strictly physiological standpoint. It opens with an excellent history of the processes of natural digestion in their several stages, including, of course, the constitution of foods, and their transformations under the influence of the digestive secretions. From this point the author passes on in successive chapters to the consideration of Primary Indigestion, Artificial Digestion, Ferments, Tissue Nutrition, Secondary Indigestion, Diet and Drink, the Functions of the Liver, Liver Disturbance, Biliousness, and the Medicinal and Dietetic Treatment of Liver Derangements. The subject will be pursued in another volume devoted to the consideration of Gout.

The author holds that disturbances of digestion are terribly on the increase in the present day, and he adds a valuable appendix on "the failure of the digestive organs at the present time," and on the "failure of nutrition in children."

We have said that this volume has been made for physicians, but it would be a mistake to infer that it had been exclusively prepared for them, and will not be of great value to non-professional readers. The information it contains ought to be widely diffused, and persons of ordinary intelligence can learn a great deal from it that will be of the highest practical use. It can not, of course, be mastered without study, but no subject will better repay careful attention. The general ignorance in relation to foods, their composition, preparation, and physiological effects, and the causes of indigestion in its various forms, is something lamentable, and the daily practice that results from this ignorance is almost heathenish. There are, moreover, abundance of quackish books on these subjects which so mislead people that they are worse than nothing. It is, therefore, important that the circulation of really valuable volumes on such topics as the one before us should be in every way promoted.

Ranthorpe. By George Henry Lewes. New York: William S. Gottsberger. Pp. 326. Price, 75 cents.

There are not many novels that survive their generation; they generally fall into an early and deserved oblivion. Mr. Lewes was not eminent as a novelist, his efforts in this direction being, indeed, regarded rather as failures than successes; but, after the lapse of a generation, his first essay of this kind reappears in a new and American edition. Mr. Lewes began with novel-writing, went on into dramatic composition, passed from this to philosophy, and finally emerged in the field of science. His novels,

therefore, do not embody the results of his long and varied studies, but they have the interest of being his first and freshest intellectual work. "Ranthorpe" was written at the age of twenty-five, though it was published five years later, in 1847. He says, in the preface, after acknowledging the defects of the book: "That the faults are not *more* numerous is owing to the admirable criticisms of two eminent friends, who paid me the compliment of being frankly severe on the work submitted to their judgment. Sensible of the kindness in their severity, I have made them what, for an author, must be considered as a magnificent acknowledgment—I have adopted all their suggestions"!

It is not difficult to explain why "Ranthorpe" was not a success in the ordinary sense of a popular novel; but the explanation will probably give the reason why it has been since recalled to the attention of the reading world. It was of too didactic a quality to suit the tastes of novel-readers in search of mere sensation. It is full of moralizings, and, although the topics are secular enough, it is rather preachy. But there is a good deal of wisdom in it that is not without its use. The hero of the book runs a literary career, goes first into poetry and fails, then into the drama, and his tragedy is d——d. The main interest of the volume is in the copious side discussions on the causes of failure in literary adventure, and we have a vivid and readable illustration of ideas which the author subsequently developed in his review articles on "The Principles of Success in Literature." From this point of view the book is instructive, while the plot keeps up the reader's interest in the usual way.

Sewer-Gas and its Dangers; with an Exposition of Common Defects in House-Drainage, and Practical Information relating to their Remedy. By George Preston Brown. Chicago: Jansen, McClurg & Co. Pp. 242. Price, $1.25.

This work is the result of investigations made by an impartial inquirer in the city of Chicago into the extent to which sewer-gas is responsible for sickness and discomfort. An amazing prevalence of defects of all kinds in the construction and working of the house-drains was discovered, of which the dwellers in the houses generally seemed unconscious. The conditions were not exceptional or peculiar to Chicago, but may be considered as general and common to all large towns in which the improvements suggested by the most recent experience and knowledge have not been adopted. Many particular defects are described, and cases of sickness that were traced to them noticed. Illustrations are given of bad drainage in actual houses whose appearance promised a better condition. The dangers which bad sewers and drains entail are forcibly presented; and suggestions are given for remedying and preventing the evils which they occasion.

The Wilderness-Cure. By Marc Cook, author of "Camp Lou." New York: William Wood & Co. Pp. 153. Price, $1.

"Camp Lou" was a magazine article which related how the author, being in a decline with lung-disease, was restored to health by camping in the Adirondacks. It called out more inquiries for minor details than the writer could answer individually, and he has therefore put all the information that was sought in the questions in this little volume. The book describes the "Wilderness" country and the conditions of the camp; considers the practicability of weak persons wintering in the region described, furnishes a summary of several cases that have been treated in the method recommended, or one like it, and considers the questions of necessary outfit and expense.

A Text-Book of Anatomy, Physiology, and Hygiene. By J. T. Scovell. Terre Haute, Indiana: Moore & Langen, Printers. Pp. 88, with six plates.

This work is designed as a text-book, to be supplemented with the study of other works more completely discussing the points considered, of which a partial list is given. It presents the principles of the science plainly, clearly, and briefly, in well-framed sentences, and is arranged after a logical classification of the divisions and subdivisions of the subject. In addition to this, the section on hygiene is practical. The illustrations are given in engravings in separate plates.

PUBLICATIONS RECEIVED.

Extra Census Bulletin. Report on the Cotton Production of the State of Louisiana. By Eugene W. Hilgard. Illustrated. Washington: Government Printing-Office. 1881. Pp. 99.

Studies in Astronomy. By Arthur K. Bartlett. Published by the author. Battle Creek, Michigan. Pp. 56. Price, 35 cents.

"The Utah Review." Rev. Theophilus Hilton, A. M., Editor Vol. I, No. 1. July, 1881. Salt Lake: H. P. Palmerston & Co. Monthly. Pp. 31. $2 a year.

Report of Field Experiments with Fertilizers. By Professor W. O. Atwater. 1880. From the Report of the Connecticut Board of Agriculture. Pp. 56.

First Annual Report of the Astronomer in charge of the Horological and Thermometric Bureaus of the Winchester Observatory of Yale College. By Leonard Waldo. New Haven. 1881. Pp. 32.

"The Journal of the American Agricultural Association." Vol. I, No. 1. Joseph H. Reall, Editor. New York. Published by the Association. 1881. Pp. 260.

Report on Hawaiian Leprosy. By A. W. Saxe, M. D. Illustrated. Santa Clara, California. 1881. Pp. 26.

To the English-speaking Populations in America, Europe, Asia, Africa, and Oceanica, concerning Testimonials on "Origin, Progress, and Destiny of the English Language and Literature." By John A. Weisse, M. D. New York: J. W. Bouton. 1881. Pp. 49.

Proceedings of the California Pharmaceutical Society and College of Pharmacy, and Report of the Twelfth Annual Meeting held at San Francisco, January 13, 1881. San Francisco: Joseph Winterburn & Co. 1881. Pp. 66.

The Reasoning Faculty of Animals. By Joseph F. James. Reprint from "The American Naturalist." Pp. 12.

A Great Lawyer. By Charles C. Bonney. Chicago: Legal News Co. 1881. Pp. 12.

"The Hour-Glass: A Popular Weekly Illustrated Journal." Chicago: Everett W. Fish & Co. Vol. I, No. 4. July 30, 1881. Pp. 6. 50 cents a year.

Report of Professor Spencer F. Baird, Secretary of the Smithsonian Institution, for the Year 1880. Washington: Government Printing-Office. 1881. Pp. 83.

On Maximum Synchronous Glaciation. By W. J. McGee. Salem, Massachusetts. 1881. Pp. 65.

A Memoir upon Loxolophodon and Uintatherium. By Henry F. Osborn, Sc. D. Accompanied by Stratigraphical Report of the Bridge Beds in the Washakee Basin. By J. B. McMaster, C. E. Illustrated. Princeton, New Jersey. Pp. 54.

Report of the Chief of the Bureau of Statistics for Three Months, ending March 31, 1881. Washington: Government Printing-Office. 1881. Pp. 100.

The University of Texas. By Professor Alexander Hogg. Pp. 7.

Circulars of Information of the Bureau of Education. Nos. 6 and 7, 1880, and 1 and 2, 1881. Washington: Government Printing-Office. 1881.

Fashion in Deformity. By Professor W. H. Flower. London: Macmillan & Co. 1881. Pp. 85. 75 cents.

The Foreigner in China. By L. N. Wheeler, D. D. Chicago: S. C. Griggs & Co. 1881. Pp. 268. $1.25.

The Bible and Science. By T. Lauder Brunton, M. D., F. R. S. London: Macmillan & Co. 1881. Pp. 415. $2.50.

A Sketch of Ancient Philosophy, from Thales to Cicero. By Joseph B. Mayor, M. A. Cambridge: University Press. 1881. Pp. 254. 75 cents.

Botany. Outlines of Morphology, Physiology, and Classification of Plants. By W. R. McNab, M. D., F. L. S. Revised for American Students by Charles E. Bessey, Ph. D. Pp. 400. $1.10. And English History for Young Folks. By S. R. Gardiner. Revised for American Students. Pp. 457. $1. New York: Henry Holt & Co. 1881.

The Microscope and its Revelations. By William B. Carpenter. Sixth edition. Philadelphia: Presley Blakiston. 1881. Pp. 882. $5.50.

Catalogue of 1,098 Standard Clock and Zodiacal Stars. Prepared under the Direction of Professor Simon Newcomb. Pp. 314.

Indigestion and Biliousness. By J. Milner Fothergill, M. D. New York: William Wood & Co. 1881. $2.

The Ancient Bronze Implements, Weapons, and Ornaments of Great Britain and Ireland. By John Evans, D. C. L., F. R. S. New York: D. Appleton & Co. 1881. Pp. 509. Illustrated, $5.

POPULAR MISCELLANY.

The American Association at Cincinnati.—The thirtieth meeting of the American Association for the Advancement of Science began at Cincinnati August 17th, and was one of the largest and every way most successful that the body has held. There was an unusually strong influx of new members, and the regular working force of the Association was well represented. The papers were many and varied, and some of them results of able investigation, and showing a well-sustained activity of original research. As regards provision for the social entertainment of the members, Cincinnati demonstrated that it understands this matter quite as well as Boston, and is not to be outdone. Every arrangement for the comfort and the pleasure of the scientists was perfect, and those who experienced them will long remember the enjoyments of the occasion. We can not, of course, report the work, and can only refer to some of the more important papers.

The meeting began with a welcoming address by Judge J. D. Cox, of Cincinnati, and a response by President Brush. The anthropological and archæological departments were fully represented, a large proportion of the most instructive and most novel papers bearing upon that subject. The proceedings of this sub-section were opened with an important and highly interesting address by the chairman, Colonel Garrick Mallery, on "The

Gesture-Speech of Man." Professor Mason read a paper on "The Uncivilized Mind in the Presence of Higher Phases of Civilization," the more immediate bearing of which was on the subject of Indian education; Horatio Hale, in "A Lawgiver of the Stone Age," sought, among other things, to inquire whether mental capacity increases with the progress of civilization, introducing in illustration the condition of the Iroquois when first visited by Europeans; Major William I. Beebe, of Brooklyn, read a paper of suggestive import on "The Decipherment of Inscriptions from the Mounds," to which we have referred more fully in another place; Mr. W. J. Hoffmann discussed "The Interpretation of Pictographs by the Application of Gesture-Signs"; Mr. Watson C. Holbrook, "Prehistoric Hieroglyphics"; while Mrs. E. A. Smith communicated the results of her researches on the "Animal Myths of the Iroquois." Dr. Stephen D. Peet contributed observations on "The Emblematic Mounds of the Four Lakes of Wisconsin," and on the "Buffalo Drives on the Rock River, in Wisconsin," a paper which provoked considerable discussion. Judge John G. Henderson discussed "Agriculture and Agricultural Implements of the Ancient Inhabitants of the Mississippi Valley"; and Mr. De Saas, of the Bureau of Ethnology, Washington, summarized the whole subject in his paper on the "Progress of Archæological Discovery." After this a resolution was passed, and referred to the Standing Committee, asking Congress to continue the appropriations for investigations relating to the mound-builders and to prehistoric mounds. The Association resolved to exercise its influence to preserve the great mound at Cahokia, Illinois, which is about to be sold; and excursions were made to Fort Ancient, one of the best-known earthworks in the Ohio Valley, and to Madisonville, where some very interesting discoveries have recently been made. In the microscopical department, Dr. G. M. Sternberg, of Baltimore, offered contributions to the study of bacterial organizations commonly found on mucous surfaces and in the alimentary canal of healthy individuals, in which he combated the opinion that each disease is produced by a microbe peculiar to itself. He had never found living organisms in blood, healthy or diseased, but the alimentary canal was never without parasites. Dr. Lester Curtis, of Chicago, gave the results of the study of the blood of Griscom, who fasted forty-five days at Chicago, the genuineness of whose fast he attested; the blood appeared healthy in every particular throughout the fast and at its end. Among the papers on subjects of physics were one "On the Cause of the Arid Climate of the Far West," by Captain C. E. Dutton; one on "The Effect of Prolonged Stress on the Strain in Timber," by Professor R. H. Thurston; and one on "Standard Time," by Professor E. B. Elliott, of Washington. A committee which had been appointed to consider the latter subject presented majority and minority reports. The former, by Professor Stone, favored a single standard for the whole country; the latter, by Professor Waldo, favored a number of standards, beginning with New York for the East, another at St. Louis, an hour later, for the Central West, and others at points farther West, each exactly an hour later than the preceding one, and suggesting that the New York standard be fixed at five hours after Greenwich time. The two reports were ordered published, to be considered at Montreal next year. H. C. Hovey presented a paper on "Coal-Dust as an Element of Danger in Mining," as shown by the late explosion in the Albion mines in Nova Scotia. Mrs. A. B. Blackwell read a paper on "The Constitution of the Atom of Science"; and Dr. H. B. Parsons, in a paper on the "Composition and Quality of American Wines," drew the conclusion that wines of American manufacture are in many cases as good as or better than more expensive foreign wines of the same general character. W. H. Ballou, of Evanston, Illinois, reviewed the "Natural and Industrial History of the White Pine of Michigan," and predicted that, at the present rate of usage, the supply of timber will disappear in seven years. Mr. Charles Sedgwick Minot, by an inquiry whether man is anatomically the highest animal, excited considerable discussion, in which, the newspaper report tells us, "some feeling was unfortunately created." David D. Thompson, of Cincinnati, considered the "Influence of Forests on Water-Courses," and W. J. Beal communi-

cated his observations of "The Motion of Roots in germinating Indian Corn." The chairman of the entomological sub-section, reviewing the growth of entomology in the United States, said that while forty years ago there were but ten working entomologists south of New York, the "Naturalists' Directory" for 1880 contains the names of four hundred and thirty-six entomologists. Professor Riley announced some novel views on the sudden appearances of the grasshopper pest, which seemed to indicate that he saw in them illustrations of the doctrine of evolution. A resolution was adopted disapproving the conferring of the degree of Ph. D. except after examination; and a committee was appointed to coöperate with the committee of the American Philological Association in addressing a memorial to the Boards of Trustees of all the colleges, asking them to discontinue the practice. The next meeting of the Association was appointed to be held at Montreal, August 23, 1882. The following officers were elected for the ensuing year: President, Dr. J. W. Dawson, of Montreal, Canada; Permanent Secretary, Professor Putnam, of Cambridge, to continue; General Secretary, William Saunders, of London, Ontario; Assistant General Secretary, Professor J. Eastman, of Washington, D. C.; Vice-President and Chairman of Section A, Professor William Harkness, of Washington; Section B, Professor T. C. Mendenhall, of Columbus, Ohio. Treasurer, William S. Vaux, of Philadelphia. A new committee on Geological Survey was appointed, consisting of Professors Swallow, Proctor, James, Hull, Winchell, Kerr, and Orton, and Major Powell. Steps were taken during the meeting toward the organization of a distinct Association of American Geologists.

Physiological Effects of Compressed Air.—Professor C. M. Woodward, of Washington University, St. Louis, Missouri, has written a book on the St. Louis Bridge, and in it has devoted a chapter to the review of the affections which the men employed in sinking the piers of the bridge suffered from compressed air, and the theories that were proposed to account for the trouble. From advance sheets of this chapter kindly furnished by the author, we learn that no serious drawback was perceived to working four or even six hours consecutively in the air-chamber till the cutting-edge of the caisson of the east pier was nearly sixty feet below the surface of the river. From that time on the working-time was gradually shortened and the rests were made longer, till the 5th of February, at sixty-five feet, when the work-time was made three watches of two hours each, with two-hour rests. The first effect noticed upon the men was a muscular paralysis of the lower limbs, without pain, which would pass off in a day or two, but which became more difficult to subdue, more extended and painful, as the caisson was sunk deeper. It was joked about among the men at first, but became more serious by the middle of February, after which, the depth being seventy-six feet, severe cases became more frequent. The superintendent noticed the fact that the sick men were often thinly clad and poorly fed. At the end of March, several persons having died within a few days shortly after coming out of the excavations, Dr. A. Jaminet was appointed to take medical charge of the men and establish such regulations as in his judgment their well-being demanded. He had been a frequent visitor to the air-chamber, had noticed the men as they came out, and had observed that their appearance was pallid and cold; that in some the pulse was quick but somewhat weak, while with others it was as low as sixty, and that without exception the workmen complained of fatigue; also that the pulse always quickened on entering the air-chamber, though it soon fell to the normal rate, and even lower; that the number of respirations increased and a feeling of exhilaration came on in the air-chamber, and that the workmen sweated profusely during their stay in it, although the temperature was often below 60° Fahr. The air-lock was, as a rule, excessively warm when the pressure was increasing, and excessively cold when the pressure was diminishing. On the day the caisson touched the rock, when the pressure was forty-five pounds above the normal, Dr. Jaminet was conscious of a great loss of heat and a violent pain in his head while in the air-lock on his way out; he had much difficulty in getting to his carriage, and became partly

paralyzed after he reached home, so that he considered his life in danger. All the precautions suggested by experience and careful observation were adopted for the protection of the men, and the cases of affection were watched as they occurred. In all, with six hundred men employed, one hundred and nineteen cases important enough to need medical treatment were reported at both piers, fourteen of which cases died and two were crippled. *Post-mortem* examinations were held in the cases of eight. Various theories have been proposed to account for the affection. Dr. Clark, of the City Hospital at St. Louis, believed that the congestion observed was caused by the forcing of the blood in upon the interior organs of the body in consequence of the increased atmospheric pressure. Another physician thought the men were poisoned by carbonic acid which had been abnormally retained within the system while in the air-chamber, but which was set free as soon as the pressure was removed. Dr. Jaminet thought the cases were due to physical exhaustion caused by breathing an atmosphere of quadruple strength, and supported his view by reference to the facts, all of which seemed to agree with it. Professor Woodward does not contradict his theory, but suggests in addition that the vital energies of the men taken sick were to a great extent paralyzed by loss of heat, which was due—1. To the expansion of the air in the lock while coming out; 2. To the expansion of the free gases and vapors within the body when relieved of the abnormal pressure; 3. To the liberation of the gases held in solution by the liquids of the body; 4. To the severe physical effort of climbing the stairs. The loss of heat taking place under diminution of pressure from four atmospheres to one would, if no heat were received from surrounding objects, be enough to reduce the temperature from 70° above to 106° below zero. Taking into consideration the condition of men who have been working hard, especially if they have not been well clothed and fed, it is not strange that they did, but rather that more of them did not, succumb under the combined effects of these four agencies. Dr. Jaminet gives an implied confirmation of these views by remarking in his pamphlet that "the paresis is but the result of reflex action caused by the spontaneous refrigeration of the whole system, but principally of all the abdominal organs." It is also worthy of remark that none of the men were ever attacked on entering the caisson, and none were ever sick while in the air-chamber, no matter how long the watch, but the attack always came on within half an hour after leaving the air-lock, or at the time. On the basis of this theory Professor Woodward establishes a system of rules for the management of men at work in compressed air, embodying the principles that only sound men should be employed, that they should be guarded against exhaustion, that they should not be exposed with unnecessary suddenness to the change from a compressed to the normal atmosphere; and that such a supply of heat should be given every man that he could lose a large amount and still have plenty left.

The Study of Anthropology.—M. P. Topinard classifies the anthropological sciences in three divisions. The first division, anthropology proper, is general, considering the questions of man's place in nature, and his origin, whether by special creation, or by derivation from preëxisting forms; and special, considering types, the classification and origin, the laws of the formation, development, death, and renewal of races. To the second division he gives the name of ethnography. It concerns the agglomerations of peoples, hordes, and tribes as we meet them. Its interest is derived from questions that are peculiar to it, and from the fact that races do not exist in nature, but are only abstractions, characterized by types which we imagine to have existed among ancestors. Nowhere can the real existence of a race be discovered, but we find two or three types, even among the most savage and most isolated tribes. Special ethnography relates to the description of each people; general ethnography to common questions of manners, customs, aptitudes, industries, beliefs, institutions; to the past of the race, the environment, circumstances in the evolution of humanity; to sociology. The third division includes the complementary sciences, among which archæology, especially prehistoric archæology, holds the first rank. It fur-

nishes us what we can learn of the primitive man, and is gradually bringing us nearer to the epoch when the races started pure. History adds legends and definite movements, records the acts and voyages of antiquity, and discloses the relations of ancient to modern races. The descriptions of the Scythians by Herodotus, of the Germans by Tacitus, of the Goths by Jornandes, of the Anglo-Saxons by Amédée Thierry, are examples of its direct relation. In return, history receives a certain degree of light from anthropology, and the hereditary influence of the physiological characters of races plays an important part in the present order. Linguistics, which should not be confounded with philology, helps to fill the gaps left by history and archæology, by indicating the passage of a people through a particular region. Deductions should be made from it with careful consideration, for they are worth no more than those which may be drawn from a custom, a mythological form, or a funeral rite. A language may advance or retire without involving the question of anthropology. We pass for Aryans, because our ancestors spoke an Aryan language; but that language may have been brought to them from the East by a small, more highly-civilized group. The group disappeared, the language remained with the aborigines. Demography is an anthropological science, related to ethnography. A fourth division might be added, consisting of sciences to be consulted. Among them might be included geography, as showing the distribution of peoples, and the topographical conditions of their surroundings; comparative law, as illustrating their social and legislative organizations; architecture and music, which show that all people and races have not had the same sentiments; sculpture, etc. The studies of anthropology, whose final object is to solve the problems of the evolution of the human race and man's place in nature, begin with analysis, or the examination of particular characteristics. Human characteristics may be arranged, according to their bearing on anthropology and ethnography, in five orders: External physical traits; internal physical traits; physiological traits; pathological traits; and ethnic traits. The last include all that can distinguish one people from another, whether relating to race, surroundings, tradition, or other points. Among them may be indicated polygamy, polyandry, monogamy, burial customs, the Indian custom of scalping, Polynesian *taboo*, the use of bows and arrows and of the boomerang, artificial deformations of the skull, etc. Thus the principal anthropological studies may be said to turn round four centers: the characteristic, the type, the race, and the human species.

The Great Primitive European Sea.—The theory of the former existence of a great sea embracing the basins of the Black, Caspian, and Aral Seas, has been confirmed by the recent ichthyological investigations of the Russian academician Kessler. This sea in the Miocene period, resting on a bottom of Eocene chalk and Jurassic rock, extended over a bed which, beginning in the East with the Sea of Aral, included the lowlands of the Caucasus and the plains of the Pontus, reached Volhynia, Podolia, and Galicia, the flats of the lower Danube, Hungary, and Servia, and ended in the West beyond the Vienna basin. This great sea was, at least in the latter part of its existence, brackish, and was connected (though some dispute this), as northern species among the fosils indicate, either through a strait or by overflow, with the Arctic Ocean. The area of the sea was still more extensive in the Eocene period, and in the Jurassic time it seems to have included all of central Russia and reached to Courland. The separation of the Aral and Caspian Seas from the Black Sea took place very early, probably during the Pliocene age, certainly before the beginning of the last geological period. The connection of the Black Sea with the Mediterranean through the present straits was made considerably later. The separation was accompanied with a decrease in the saltness of the Eastern seas—the Black Sea now containing 1·6 per cent., the southern part of the Caspian Sea 1·3 per cent., the Sea of Aral 1·1 per cent. of salt—and a slight modification of their fauna. The fauna of the Black Sea can not be regarded as an impoverished fraction of that of the Mediterranean, but is of independent origin, consisting of what remains from the primi-

tive sea, to which a few Mediterranean forms have since been added. The fauna of the Caspian is analogous to that of the Black Sea, but without the Mediterranean species. Since this sea is composed of brackish water, and is fresh in the northern part, it can contain only those species which live in brackish water or are indifferent or migratory, with no real sea-fishes. The ichthyology of the Sea of Aral has only recently been determined. It is entirely of a fresh-water character.

NOTES.

Mr. M. L. Wadsworth has published at Cambridge, Massachusetts, the results of a microscopical study of the iron-ore, or peridotite, of Iron-Mine Hill, Cumberland, Rhode Island, a valuable ore similar to the ore of Tagberg, Sweden, of which an immense quantity occurs in mass. He also, in the same pamphlet, describes a gold-mine, which is worked for its gold, in the quartz veins of the diabase of Sullivan, Hancock County, Maine.

Mr. Alfred Neighbour, apiarian, of London, has made a successful shipment of queen humble-bees to New Zealand. Of eighteen bees which were sent on the 7th of December last, two were alive and strong when the lot reached the consignee on the 3d of February, and flew at once against the wind into the clover-fields. These are the first humble-bees that have ever lived in New Zealand, all former attempts to ship and acclimatize the insects having failed.

A movement is on foot in England, and is receiving the countenance and support of members of Parliament, to reduce the time of labor of railway employees to nine hours a day. In behalf of the change it is urged that the duties of the men, and especially those performed by the engineers and signal-men, are of a nature to require the keenest and most unflagging attention, and that this can not be given for many hours continuously without great fatigue, and a consequent diminution of the alertness and care necessary to the safety of life and property.

While other nations of Europe, and the United States, have established stations around the north pole for the study of terrestrial magnetism, France is about to establish one among the islands of Cape Horn. Credits for this purpose are to be asked of the Chambers, and it is anticipated that the expedition will go out in the same vessel that carries the astronomers deputed to observe the transit of Venus.

Professor Trowbridge, who was appointed a committee of the New York Academy of Sciences on the subject of procuring the adoption of a uniform system of mathematical notation, or symbolization, has reported that uniformity would be very desirable, but hard to gain. It prevails essentially in pure mathematics, where the algebraic signs and the symbols of calculus are everywhere the same, but not in applied mathematics, where even the most common symbols are employed without discrimination, and according to each writer's whim and convenience. The realization of uniformity would be almost equivalent to the reconstruction of a language, and would require continued efforts and discussions. The most that the Academy can accomplish toward it at present is to take a position in favor of it.

The fifty-fourth meeting of the German Association of Naturalists and Physicians will be held in Salzburg, September 18th to 24th. Addresses will be delivered at the general meetings by Dr. von Pettenkofer, on the soil and its connection with the health of man; by Dr. von Oppolzer, of Vienna, on the sufficiency of Newton's law of gravitation to explain the motion of the heavenly bodies; and by Herr Mach, of Prague, on natural-history teaching.

The death of the eminent German botanist, Professor M. J. Schleiden, is announced. Professor Schleiden was born at Hamburg in 1804, and turned his attention to botany after having studied law. He was Professor of Botany at Jena from 1839 to 1862, and of Vegetable Chemistry and Anthropology at Dorpat in 1863 and 1864. His principal work is "Die Grundzüge der wissenschaftlichen Botanik" ("The Principles of Scientific Botany").

M. Pasteur has reported the complete success of the experiments which he has been carrying on on a large scale at a farm near Melun, France, in vaccination against carbonaceous diseases; and he believes that he has obtained a process by means of which sheep and cattle can be made wholly secure against this most dangerous and destructive class of maladies.

The report of Professor Abel on colliery explosions confirms the theory that coal-dust is an important factor in them. A mixture of coal-dust and air is not explosive, but if a quantity of fire-damp, which, mixed merely with air, would be harmless, is also present, a highly explosive atmosphere is produced. Professor Abel's experiments show that any kind of dust mixed with air, containing a small quantity of fire-damp, converts the mixture into an explosive compound.

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